A

HISTORY

OF

THE EARTH

AND

ANIMATED NATURE.

BY OLIVER GOLDSMITH.

ILLUSTRATED WITH COPPER PLATES.

WITH CORRECTIONS AND ADDITIONS

BY W. TURTON, M.D.

FELLOW OF THE LINNÆAN SOCIETY.

A NEW EDITION; IN SIX VOLUMES.

VOL. I.

LONDON:

PRINTED FOR WINGRAVE AND COLLINGWOOD; F., C., AND J. RIVINGTON; LONGMAN, HURST, REES, ORME, AND BROWN; CADELL AND DAVIES; J. NUNN; J. RICHARDSON; J. M. RICHARDSON; S. BAGSTER; J. AND A. ARCH; J. MAWMAN; J. BOOKER; BALDWIN, CRADOCK AND JOY; J. BLACK; GALE AND FENNER; WALKER AND EDWARDS; J. ROBINSON; AND B. REYNOLDS.

1816.

T. C. Hansard, Printer,
Peterborough-court, Fleet-street,
London.

ADVERTISEMENT.

OF a Work which has so long continued to give delight and instruction, it would now be superfluous to appreciate the merits, or discuss the utility. But as Natural History has been, since the original publication, much studied and much improved, it was thought that an edition correcting the known errors, and supplying the deficiences, would make it more gratifying, as it was more perfect. The whole of GOLDSMITH'S *engagingly descriptive language is preserved, and what has been added in this edition, is put between brackets.*

W. T.

PREFACE.

NATURAL History, considered in its utmost extent, comprehends two objects. First, that of discovering, ascertaining, and naming all the various productions of nature. Secondly, that of describing the properties, manners, and relations, which they bear to us, and to each other. The first, which is the most difficult part of this science, is systematical, dry, mechanical, and incomplete. The second is more amusing, exhibits new pictures to the imagination, and improves our relish for existence, by widening the prospect of nature around us.

Both, however, are necessary to those who would understand this pleasing science in its utmost extent. The first care of every inquirer, no doubt, should be, to see, to visit, and examine every object, before he pretends to inspect its habitudes or its history. From seeing and observing the thing itself, he is most naturally led to speculate upon its uses, its delights, or its inconveniencies.

Numberless obstructions, however, are found in this part of his pursuit, that frustrate his diligence and retard his curiosity. The objects in nature are so many, and even those of the same kind are exhibited in such a variety of forms, that the inquirer finds himself lost, in the exuberance before him, and, like a man who attempts to count the stars

unassisted by art, his powers are all distracted in barren superfluity.

To remedy this embarrassment, artificial systems have been devised, which grouping into masses those parts of nature more nearly resembling each other, refer the inquirer for the name of the single object he desires to know, to some one of those general distributions, where it is to be found by further examination.

If, for instance, a man should, in his walks, meet with an animal, the name, and consequently the history of which, he desires to know, he is taught by systematic writers of natural history to examine its most obvious qualities, whether a quadruped, a bird, a fish, or an insect. Having determined it, for explanation sake, to be an insect, he examines whether it has wings; if he finds it possessed of these, he is taught to examine whether it has two or four; if possessed of four, he is taught to observe, whether the two upper wings are of a shelly hardness, and serve as cases to those under them; if he finds the wings composed in this manner, he is then taught to pronounce, that this insect is one of the beetle kind: of the beetle kind, there are several different families, distinguished from each other by their antennæ or horns; he examines the insect before him, and finds that the horns are clavated or knobbed at the ends; of beetles, with the horns thus formed, there are several kinds; and among those, he is taught to look for the precise name of that which is before him. If, for instance, the knob be divided into plates at the ends, and the belly be marked with large triangular white

spots on each side, it is no other than the Cockchaffer, or the Maybug; an animal, the noxious qualities of which give it a very distinguished rank in the history of the insect creation. In this manner a system of natural history may, in some measure, be compared to a dictionary of words. Both are solely intended to explain the names of things, but with this difference, that in the dictionary of words we are led from the name of the thing to its definition; whereas, in the system of natural history, we are led from the definition to find out the name.

Such are the efforts of writers, who have composed their works with great labour and ingenuity, to direct the learner in his progress through nature, and to inform him of the name of every animal, plant, or fossil substance, that he happens to meet with; but it would be only deceiving the reader, to conceal the truth, which is, that books alone can never teach him this art in perfection; and the solitary student can never succeed. Without a master, and a previous knowledge of many of the objects in nature, his book will only serve to confound and disgust him. Few of the individual plants or animals, that he may happen to meet with, are in that precise state of health, or that exact period of vegetation, from whence their descriptions were taken. Perhaps he meets the plant only with leaves, but the systematic writer has described it in flower. Perhaps he meets the bird before it has moulted its first feathers, while the systematic description was made in its state of full perfection. He thus ranges without an instructor, confused, and with sickening curiosity, from subject to sub-

ject, till at last he gives up the pursuit, in the multiplicity of his disappointments.

Some practice, therefore, much instruction, and diligent reading, are requisite to make a ready and expert naturalist, who shall be able, even by the help of a system, to find out the name of every object he meets with. But when this tedious, though requisite part of study is attained, nothing but delight and variety attend the rest of his journey. Wherever he travels, like a man in a country where he has many friends, he meets with nothing but acquaintances and allurements in all the stages of his way. The mere uninformed spectator passes on in gloomy solitude; but the naturalist, in every plant, in every insect, and in every pebble, finds something to entertain his curiosity, and excite his speculation.

From hence it appears, that a system may be considered as a dictionary in the study of nature. The ancients, however, who have all written most delightfully on this subject, seem entirely to have rejected those humble and mechanical helps to science. They contented themselves with seizing upon the great outlines of history, and passing over what was common, as not worth the detail; they only dwelt upon what was new, great, and surprising, and sometimes even warmed the imagination at the expense of truth. Such of the moderns as revived this science in Europe, undertook the task more methodically, though not in a manner so pleasing. Aldrovandus, Gesner, and Johnson, seemed desirous of uniting the entertaining and rich descriptions of the ancients with the dry and systematic arrangement, of which they were the

first projectors. This attempt, however, was extremely imperfect, as the great variety of nature was, as yet, but very inadequately known. Nevertheless, by attempting to carry on both objects at once; first, of directing us to the name of the thing; and then, giving the detail of its history, they drew out their works into a tedious and unreasonable length; and thus mixing incompatible aims, they have left their labours, rather to be occasionally consulted than read with delight by posterity.

The later moderns, with that good sense which they have carried into every other part of science, have taken a different method in cultivating natural history. They have been content to give, not only the brevity, but also the dry and disgusting air of a dictionary to their systems. Ray, Klein, Brisson, and Linnæus, have had only one aim, that of pointing out the object of nature, of discovering its name, and where it was to be found in those authors that treated of it in a more prolix and satisfactory manner. Thus natural history, at present, is carried on in two distinct and separate channels, the one serving to lead on to the thing, the other conveying the history of the thing, as supposing it already known.

The following Natural History is written, with only such an attention to system as serves to remove the reader's embarrassments, and allure him to proceed. It can make no pretensions in directing him to the name of every object he meets with; that belongs to works of a very different kind, and written with very different aims. It will fully answer my design, if the reader, being already possessed of the name of any animal, shall find here a

short, though satisfactory history of its habitudes, its subsistence, its manners, its friendships and hostilities. My aim has been to carry on just as much method, as was sufficient to shorten my descriptions by generalizing them, and never to follow order where the art of writing, which is but another name for good sense, informed me that it would only contribute to the reader's embarrassment.

Still, however, the reader will perceive, that I have formed a kind of system in the history of every part of animated nature, directing myself by the great obvious distinctions that she herself seems to have made, which, though too few to point exactly to the name, are yet sufficient to illuminate the subject, and remove the reader's perplexity. M. Buffon, indeed, who has brought greater talents to this part of learning than any other man, has almost entirely rejected method in classing quadrupeds. This, with great deference to such a character, appears to me running into the opposite extreme: and, as some moderns have of late spent much time, great pains, and some learning, all to very little purpose, in systematic arrangement, he seems so much disgusted by their trifling, but ostentatious efforts, that he describes his animals, almost in the order they happen to come before him. This want of method seems to be a fault: but he can lose little by a criticism which every dull man can make, or by an error in arrangement, from which the dullest are the most usually free.

In other respects, as far as this able philosopher has gone, I have taken him for my guide. The warmth of his style, and the brilliancy of his imagination, are inimitable. Leaving him, therefore,

without a rival in these, and only availing myself of his information, I have been content to describe things in my own way; and though many of the materials are taken from him, yet I have added, retrenched, and altered as I thought proper. It was my intention, at one time, whenever I differed from him, to have mentioned it at the bottom of the page; but this occurred so often, that I soon found it would look like envy, and might, perhaps, convict me of those very errors which I was wanting to lay upon him. I have, therefore, as being every way his debtor, concealed my dissent, where my opinion was different; but wherever I borrow from him, I take care at the bottom of the page to express my obligations. But though my obligations to this writer are many, they extend but to the smallest part of the work, as he has hitherto completed only the history of quadrupeds. I was, therefore, left to my own reading alone, to make out the history of birds, fishes, and insects, of which the arrangement was so difficult, and the necessary information so widely diffused, and so obscurely related when found, that it proved by much the most laborious part of the undertaking. Thus having made use of M. Buffon's lights in the first part of the work, I may, with some share of confidence, recommend it to the public. But what shall I say to that part, where I have been entirely left without his assistance? As I would affect neither modesty nor confidence, it will be sufficient to say, that my reading upon this part of the subject has been very extensive; and that I have taxed my scanty circumstances in procuring books which are on the subject, of all others, the most expensive.

In consequence of this industry, I here offer a work to the public, of a kind, which has never been attempted in ours, or any other modern language, that I know of. The ancients, indeed, and Pliny in particular, have anticipated me, in the present manner of treating natural history. Like those historians who describe the events of a campaign, they have not condescended to give the private particulars of every individual that formed the army; they were content with characterising the generals, and describing their operations, while they left it to meaner hands to carry the muster-roll. I have followed their manner, rejecting the numerous fables which they adopted, and adding the improvements of the moderns, which are so numerous, that they actually make up the bulk of natural history.

The delight which I found in reading Pliny, first inspired me with the idea of a work of this nature. Having a taste rather classical than scientific, and having but little employed myself in turning over the dry labours of modern system-makers, my earliest intention was to translate this agreeable writer, and by the help of a commentary to make my work as amusing as I could. Let us dignify natural history ever so much with the grave appellation of an useful science, yet still we must confess that it is the occupation of the idle and the speculative, more than of the busy and the ambitious part of mankind. My intention, therefore, was to treat what I then conceived to be an idle subject, in an idle manner; and not to hedge round plain and simple narratives with hard words, accumulated distinctions, ostentatious learning, and dis-

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It will be my chief pride, therefore, if this work may be found an innocent amusement for those who have nothing else to employ them, or who require a relaxation from labour. Professed naturalists will, no doubt, find it superficial; and yet I should hope that even these will discover hints and remarks, gleaned from various reading, not wholly trite or elementary. I would wish for their approbation. But my chief ambition is, to drag up the obscure and gloomy learning of the cell to open inspection; to strip it from its garb of austerity, and to show the beauties of that form, which only the industrious and the inquisitive have been hitherto permitted to approach.

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CONTENTS

OF THE FIRST VOLUME.

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THE EARTH.

CHAP. I.

A Sketch of the Universe.

THE world may be considered as one vast mansion, where man has been admitted to enjoy, to admire, and to be grateful. The first desires of savage nature are merely to gratify the importunities of sensual appetite, and to neglect the contemplation of things, barely satisfied with their enjoyment: the beauties of nature, and all the wonders of creation, have but little charms for a being taken up in obviating the wants of the day, and anxious for precarious subsistence.

Philosophers, therefore, who have testified such surprise at the want of curiosity in the ignorant, seem not to consider that they are usually employed in making provisions of a more important nature; in providing rather for the necessities than the amusements of life. It is not till our more pressing wants are sufficiently supplied, that we can attend to the calls of curiosity; so that in every age

scientific refinement has been the latest effort of human industry.

But human curiosity, though at first slowly excited, being at last possessed of leisure for indulging its propensity, becomes one of the greatest amusements of life, and gives higher satisfactions than what even the senses can afford. A man of this disposition turns all nature into a magnificent theatre, replete with objects of wonder and surprise, and fitted up chiefly for his happiness and entertainment: he industriously examines all things, from the minutest insect to the most finished animal; and, when his limited organs can no longer make the disquisition, he sends out his imagination upon new enquiries.

Nothing, therefore, can be more august and striking than the idea which his reason, aided by his imagination, furnishes of the universe around him. Astronomers tell us, that this earth which we inhabit forms but a very minute part in that great assemblage of bodies of which the world is composed. It is a million of times less than the sun, by which it is enlightened. The planets also, which, like it, are subordinate to the sun's influence, exceed the earth a thousand times in magnitude. These, which were at first supposed to wander in the heavens without any fixed path, and took their name from their apparent deviations, have long been found to perform their circuits with great exactness and strict regularity. They have been discovered as forming with our earth a system of bodies circulating round the sun, all obedient to one law, and impelled by one common influence.

Modern philosophy has taught us to believe, that,

when the great Author of nature began the work of creation, he chose to operate by second causes; and that, suspending the constant exertion of his power, he endued matter with a quality by which the universal economy of nature might be continued without his immediate assistance. This quality is called *attraction;* a sort of approximating influence, which all bodies, whether terrestrial or celestial, are found to possess; and which in all increases as the quantity of matter in each increases. The sun, by far the greatest body in our system, is, of consequence, possessed of much the greatest share of this attracting power; and all the planets, of which our earth is one, are, of course, entirely subject to its superior influence. Were this power, therefore, left uncontrolled by any other, the sun must quickly have attracted all the bodies of our celestial system to itself; but it is equally counteracted by another power of equal efficacy; namely, a progressive force, which each planet received when it was impelled forward, by the divine Architect, upon its first formation. The heavenly bodies of our system being thus acted upon by two opposing powers; namely, by that of *attraction,* which draws them towards the sun; and that of *impulsion,* which drives them strait forward into the great void of space; they pursue a track between these contrary directions; and each, like a stone whirled about in a sling, obeying two opposite forces, circulates round its great centre of heat and motion.

In this manner, therefore, is the harmony of our planetary system preserved. The sun, in the midst, gives heat, and light, and circular motion to the

planets which surround it: Mercury, Venus, the Earth, Mars, Jupiter, Saturn, and Herschel or the Georgium Sidus, perform their constant circuits at different distances, each taking up a time to complete its revolutions proportioned to the greatness of the circle which it is to describe. The lesser planets also, which are attendants upon some of the greater, are subject to the same laws; they circulate with the same exactness; and are, in the same manner, influenced by their respective centres of motion.

Besides those bodies which make a part of our peculiar system, and which may be said to reside within its great circumference; there are others, that frequently come among us, from the most distant tracts of space, and that seem like dangerous intruders upon the beautiful simplicity of nature. These are comets, whose appearance was once so terrible to mankind, the theory of which is better understood at present: we know that their number is much greater than that of the planets; and that, like these, they roll in orbits, in some measure obedient to solar influence. Astronomers have endeavoured to calculate the returning periods of many of them; but experience has not, as yet, confirmed the veracity of their investigations: indeed, who can tell, when those wanderers have made their excursions into other worlds and distant systems, what obstacles may be found to oppose their progress, to accelerate their motions, or retard their return?

But what we have hitherto attempted to sketch, is but a small part of that great fabric in which the Deity has thought proper to manifest his wis-

dom and omnipotence. There are multitudes of other bodies dispersed over the face of the heavens, that lie too remote for examination: these have no motion, such as the planets are found to possess, and are, therefore, called fixed stars; and, from their extreme brilliancy and their immense distance, philosophers have been induced to suppose them to be suns, resembling that which enlivens our system; as the imagination also, once excited, is seldom content to stop, it has furnished each with an attendant system of planets belonging to itself, and has even induced some to deplore the fate of those systems, whose imagined suns, which sometimes happens, have become no longer visible.

But conjectures of this kind, which no reasoning can ascertain, nor experiment reach, are rather amusing than useful. Though we see the greatness and wisdom of the Deity in all the seeming worlds that surround us, it is our chief concern to trace him in that which we inhabit. The examination of the earth, the wonders of its contrivance, the history of its advantages, or of the seeming defects in its formation, are the proper business of the *natural historian*. A description of this earth, its *animals*, *vegetables*, and *minerals*, is the most delightful entertainment the mind can be furnished with, as it is the most interesting and useful. I would beg leave, therefore, to conclude these commonplace speculations, with an observation, which, I hope, is not entirely so.

An use, hitherto not much insisted upon, that may result from the contemplation of celestial magnificence, is, that it will teach us to make an allowance for the apparent irregularities we find below.

Whenever we can examine the works of the Deity at a proper point of distance, so as to take in the whole of his design, we see nothing but uniformity, beauty, and precision. The heavens present us with a plan, which, though inexpressibly magnificent, is yet regular beyond the power of invention. Whenever, therefore, we find any apparent defects in the earth, which we are about to consider, instead of attempting to reason ourselves into an opinion that they are beautiful, it will be wise to say, that we do not behold them at the proper point of distance, and that our eye is laid too close to the objects, to take in the regularity of their connexion. In short, we may conclude, that God, who is regular in his great productions, acts with equal uniformity in the little.

CHAP. II.

A short Survey of the Globe. from the Light of Astronomy and Geography.

ALL the sciences are, in some measure, linked with each other, and before the one is ended, the other begins. In a natural history, therefore, of the earth, we must begin with a short account of its situation and form, as given us by astronomers and geographers: it will be sufficient, however, upon this occasion, just to hint to the imagination, what they, by the most abstract reasonings, have forced upon the understanding. The earth we inhabit is, as has been said before, one of those bodies which circulate in our solar system;

it is placed at a happy middle distance from the centre; and even seems, in this respect, privileged beyond all other planets that depend upon our great luminary for their support. Less distant from the sun than Herschel, or the Georgium Sidus, Saturn, Jupiter, and Mars, and yet less parched up than Venus and Mercury, that are situate too near the violence of its power, the earth seems, in a peculiar manner, to share the bounty of the Creator: it is not, therefore, without reason that mankind consider themselves as the peculiar objects of his providence and regard.

Besides that motion which the earth has round the sun, the circuit of which is performed in a year, it has another upon its own axle, which it performs in twenty-four hours. Thus, like a chariot wheel, it has a compound motion; for while it goes forward on its journey, it is at the same time turning upon itself. From the first of these two arise the grateful vicissitude of the seasons; from the second, that of day and night.

It may be also readily conceived, that a body thus wheeling in circles, will most probably be itself a sphere. The earth, beyond all possibility of doubt, is found to be so. Whenever its shadow happens to fall upon the moon, in an eclipse, it appears to be always circular, in whatever position it is projected: and it is easy to prove, that a body, which in every position makes a circular shadow, must itself be round. The rotundity of the earth may be also proved from the meeting of two ships at sea: the top masts of each are the first parts that are discovered by both, the under parts being hidden by the convexity of the

globe which rises between them. The ships, in this instance, may be resembled to two men who approach each other on the opposite sides of a hill; their heads will first be seen, and gradually, as they come nearer, they will come entirely into view.

However, though the earth's figure is said to be spherical, we ought only to conceive it as being nearly so. It has been found, in the last age, to be rather flatted at both poles, so that its form is commonly resembled to that of a turnip. The cause of this swelling of the equator is ascribed to the greater rapidity of the motion with which the parts of the earth are there carried round; and which, consequently, endeavouring to fly off, act in opposition to central attraction. The twirling of a mop may serve as an homely illustration; which, as every one has seen, spreads, and grows broader in the middle, as it continues to be turned round.

As the earth receives light and motion from the sun, so it derives much of its warmth and power of vegetation from the same beneficent source. However, the different parts of the globe participate of these advantages in very different proportions, and accordingly put on very different appearances; a polar prospect, and a landscape at the equator, are as opposite in their appearances as in their situation.

The polar regions, that receive the solar beams in a very oblique direction, and continue for one half of the year in night, receive but few of the genial comforts which other parts of the world enjoy. Nothing can be more mournful or hideous than the picture which travellers present of

those wretched regions. The ground,* which is rocky and barren, rears itself in every place in lofty mountains and inaccessible cliffs, and meets the mariner's eye at forty leagues from shore. These precipices, frightful in themselves, receive an additional horror from being constantly covered with ice and snow, which daily seem to accumulate, and to fill all the vallies with increasing desolation. The few rocks and cliffs that are bare of snow, look at a distance of a dark brown colour, and quite naked. Upon a nearer approach, however, they are found replete with many different veins of coloured stone, here and there spread over with a little earth, and a scanty portion of grass and heath. The internal parts of the country are still more desolate and deterring. In wandering through these solitudes, some plains appear covered with ice, that, at first glance, seem to promise the traveller an easy journey.† But these are even more formidable and more unpassable than the mountains themselves, being cleft with dreadful chasms, and every where abounding with pits that threaten certain destruction. The seas that surround these inhospitable coasts, are still more astonishing, being covered with flakes of floating ice, that spread like extensive fields, or that rise out of the water like enormous mountains. These, which are composed of materials as clear and transparent as glass,‡ assume many strange and fantastic appearances. Some of them look like churches or castles, with pointed turrets; some like ships in full sail; and people have often given

* Krantz's History of Greenland, p. 3. † Ibid. 22.
‡ Ibid. 27.

themselves the fruitless toil to attempt piloting the imaginary vessels into harbour. There are still others that appear like large islands, with plains, valleys, and hills, which often rear their heads two hundred yards above the level of the sea; and although the height of these be amazing, yet their depth beneath is still more so; some of them being found to sink three hundred fathom under water.

The earth presents a very different appearance at the equator, where the sun-beams, darting directly downwards, burn up the lighter soils into extensive sandy deserts, or quicken all the moister tracts with incredible vegetation. In these regions, almost all the same inconveniencies are felt from the proximity of the sun, that in the former were endured from its absence. The deserts are entirely barren, except where they are found to produce serpents, and in such quantities, that some extensive plains seem almost entirely covered with them.*

It not unfrequently happens, also, that this dry soil, which is so parched and comminuted by the force of the sun, rises with the smallest breeze of wind; and the sands being composed of parts almost as small as those of water, they assume a similar appearance, rolling onward in waves, like those of a troubled sea, and overwhelming all they meet with inevitable destruction. On the other hand, those tracts which are fertile, teem with vegetation even to a noxious degree. The grass rises to such a height, as often to require burning; the forests are impassable from underwoods,

* Adanson's Description of Senegal.

and so matted above, that even the sun, fierce as it is, can seldom penetrate.* These are so thick, as scarcely to be extirpated; for the tops being so bound together by the climbing plants that grow round them, though a hundred should be cut at the bottom, yet not one would fall, as they mutually support each other. In these dark and tangled forests, beasts of various kinds, insects in astonishing abundance, and serpents of surprising magnitude, find a quiet retreat from man, and are seldom disturbed, except by each other.

In this manner the extremes of our globe seem equally unfitted for the comforts and conveniencies of life; and, although the imagination may find an awful pleasure in contemplating the frightful precipices of Greenland, or the luxurious verdure of Africa, yet true happiness can only be found in the more moderate climates, where the gifts of nature may be enjoyed without incurring danger in obtaining them.

It is in the temperate zone, therefore, that all the arts of improving nature, and refining upon happiness, have been invented: and this part of the earth is, more properly speaking, the theatre of natural history. Although there be millions of animals and vegetables in the unexplored forests under the line, yet most of these may for ever continue unknown, as curiosity is there repressed by surrounding danger. But it is otherwise in these delightful regions which we inhabit, and where this art has had its beginning. Among us there is scarcely a shrub, a flower, or an insect, without its

* Linnæi Am. vol. vi. p. 67.

particular history; scarcely a plant that could be useful, which has not been propagated; nor a weed that could be noxious, which has not been pointed out.

CHAP. III.

A View of the Surface of the Earth.

WHEN we take a slight survey of the surface of our globe, a thousand objects offer themselves, which, though long known, yet still demand our curiosity. The most obvious beauty that every where strikes the eye, is the verdant covering of the earth, which is formed by a happy mixture of herbs and trees of various magnitudes and uses. It has been often remarked that no colour refreshes the sight so much as green; and it may be added, as a further proof of the assertion, that the inhabitants of those places where the fields are continually white with snow, generally become blind long before the usual course of nature.

This advantage, which arises from the verdure of the fields, is not a little improved by their agreeable inequalities. There are scarcely two natural landscapes that offer prospects entirely resembling each other; their risings and depressions, their hills and valleys, are never entirely the same, but always offer something new to entertain and refresh the imagination.

But to increase the beauties of the face of nature, the landscape is enlivened by springs and lakes, and intersected by rivulets. These lend a brightness to the prospect; give motion and cool-

ness to the air; and, what is much more important, furnish health and subsistence to animated nature.

Such are the most obvious and tranquil objects that every where offer: but there are objects of a more awful and magnificent kind; the *Mountain* rising above the clouds, and topped with snow; the *River* pouring down its sides, increasing as it runs, and losing itself, at last, in the ocean; the *Ocean* spreading its immense sheet of waters over one half of the globe, swelling and subsiding at well-known intervals, and forming a communication between the most distant parts of the earth.

If we leave those objects that seem to be natural to our earth, and keep the same constant tenour, we are presented with the great irregularities of nature. The burning mountain; the abrupt precipice; the unfathomable cavern; the headlong cataract; and the rapid whirlpool.

If we carry our curiosity a little further, and descend to the objects immediately below the surface of the globe, we shall there find wonders still as amazing. We first perceive the earth, for the most part, lying in regular beds or layers, every bed growing thicker in proportion as it lies deeper, and its contents more compact and heavy. We shall find, almost wherever we make our subterranean inquiry, an amazing number of shells that belonged to aquatic animals. Here and there, at a distance from the sea, beds of oyster-shells, several yards thick, and many miles over; sometimes testaceous substances of various kinds on the tops of mountains, and often in the heart of the hardest marble. These, which are dug up by the peasants in every country, are regarded with

little curiosity; for, being so very common, they are considered as substances entirely terrene. But it is otherwise with the inquirer after nature, who finds them, not only in shape but in substance, every way resembling those that are found in the sea; and he, therefore, is at a loss to account for their removal.

Yet not one part of nature alone, but all her productions and varieties, become the object of the speculative man's inquiry: he takes different views of nature from the inattentive spectator; and scarcely an appearance, how common soever, but affords matter for his contemplation: he inquires how and why the surface of the earth has those risings and depressions which most men call natural; he demands in what manner the mountains were formed, and in what consists their uses; he asks from whence springs arise, and how rivers flow round the convexity of the globe; he enters into an examination of the ebbings and flowings, and the other wonders of the deep; he acquaints himself with the irregularities of nature, and endeavours to investigate their causes; by which, at least, he will become better versed in their history. The internal structure of the globe becomes an object of his curiosity; and, although his inquiries can fathom but a very little way, yet, if possessed with a spirit of theory, his imagination will supply the rest. He will endeavour to account for the situation of the marine fossils that are found in the earth, and for the appearance of the different beds of which it is composed. These have been the inquiries that have splendidly employed many of the philosophers of the last and

present age;* and, to a certain degree, they must be serviceable. But the worst of it is, that, as speculations amuse the writer more than facts, they may be often carried to an extravagant length; and that time may be spent in reasoning upon nature, which might be more usefully employed in writing her history.

Too much speculation in natural history is certainly wrong; but there is a defect of an opposite nature that does much more prejudice; namely, that of silencing all inquiry, by alleging the benefits we receive from a thing, instead of investigating the cause of its production. If I inquire how a mountain came to be formed, such a reasoner, enumerating its benefits, answers, because God knew it would be useful. If I demand the cause of an earthquake, he finds some good produced by it, and alleges that as the cause of its explosion. Thus, such an inquirer has constantly some ready reason for every appearance in nature, which serves to swell his periods, and give splendour to his declamation: every thing about him is, on some account or other, declared to be good; and he thinks it presumption to scrutinize its defects, or endeavour to imagine how it might be better. Such writers, and there are many such, add very little to the advancement of knowledge. It is finely remarked by Bacon, that the investigation of final causes† is a barren study; and, like a vir-

* Buffon, Woodward, Burnet, Whiston, Kircher, Bourquat, Leibnitz, Steno, Ray, &c.

† Investigatio causarum finalium sterilis est, et veluti virgo Deo dedicata, nil parit.

gin dedicated to the Deity, brings forth nothing. In fact, those men who want to compel every appearance and every irregularity in nature into our service, and expatiate on their benefits, combat that very morality which they would seem to promote. God has permitted thousands of natural evils to exist in the world, because it is by their intervention that man is capable of moral evil; and he has permitted that we should be subject to moral evil, that we might do something to deserve eternal happiness, by showing we had rectitude to avoid it.

CHAP. IV.

A Review of the different Theories of the Earth.

HUMAN invention has been exercised for several ages to account for the various irregularities of the earth. While those philosophers, mentioned in the last chapter, see nothing but beauty, symmetry, and order; there are others, who look upon the gloomy side of nature, enlarge on its defects, and seem to consider the earth, on which they tread, as one scene of extensive desolation.* Beneath its surface they observe minerals and waters confusedly jumbled together; its different beds of earth irregularly lying upon each other; mountains rising from places that once were level,† and hills sinking into vallies; whole regions swallowed by the sea, and others again

* Buffon's Second Discourse.

† Senec. Quæst. lib. vi. cap. 21.

rising out of its bosom: all these they suppose to be but a few of the changes that have been wrought in our globe; and they send out the imagination, to describe its primæval state of beauty.

Of those who have written theories describing the manner of the original formation of the earth, or accounting for its present appearances, the most celebrated are Burnet, Whiston, Woodward, and Buffon. As speculation is endless, so it is not to be wondered that all these differ from each other, and give opposite accounts of the several changes which they suppose our earth to have undergone. As the systems of each have had their admirers, it is, in some measure, incumbent upon the natural historian to be acquainted, at least, with their outlines; and, indeed, to know what others have even dreamed, in matters of science, is very useful, as it may often prevent us from indulging similar delusions ourselves, which we should never have adopted, but because we take them to be wholly our own. However, as entering into a detail of these theories is rather furnishing an history of opinions than things, I will endeavour to be as concise as I can.

The first who formed this amusement of earth-making into system, was the celebrated Thomas Burnet, a man of polite learning and rapid imagination. His *Sacred Theory*, as he calls it, describing the changes which the earth has undergone, or shall hereafter undergo, is well known for the warmth with which it is imagined, and the weakness with which it is reasoned, for the elegance of its style, and the meanness of its philosophy. The earth, says he, before the deluge,

was very differently formed from what it is at present: it was at first a fluid mass; a chaos composed of various substances, differing both in density and figure: those which were most heavy sunk to the centre, and formed in the middle of our globe a hard solid body; those of a lighter nature remained next; and the waters, which were lighter still, swam upon its surface, and covered the earth on every side. The air, and all those fluids which were lighter than water, floated upon this also; and in the same manner encompassed the globe; so that between the surrounding body of waters, and the circumambient air, there was formed a coat of oil, and other unctuous substances, lighter than water. However, as the air was still extremely impure, and must have carried up with it many of those earthy particles with which it once was intimately blended, it soon began to defecate, and to depose these particles upon the oily surface already mentioned, which soon uniting, the earth and oil formed that crust which soon became an habitable surface, giving life to vegetation, and dwelling to animals.

This imaginary antediluvian abode was very different from what we see it at present. The earth was light and rich; and formed of a substance entirely adapted to the feeble state of incipient vegetation: it was an uniform plain, every where covered with verdure; without mountains, without seas, or the smallest inequalities. It had no difference of seasons, for its equator was in the plain of the ecliptic, or, in other words, it turned directly opposite to the sun, so that it enjoyed one perpetual and luxuriant spring. How-

ever, this delightful face of nature did not long continue in the same state, for, after a time, it began to crack and open in fissures: a circumstance which always succeeds when the sun exhales the moisture from rich or marshy situations. The crimes of mankind had been for some time preparing to draw down the wrath of Heaven; and they, at length, induced the Deity to defer repairing these breaches in nature. Thus the chasms of the earth every day became wider, and, at length, they penetrated to the great abyss of waters; and the whole earth, in a manner, fell in. Then ensued a total disorder in the uniform beauty of the first creation, the terrene surface of the globe being broken down: as it sunk, the waters gushed out in its place; the deluge became universal; all mankind, except eight persons, were destroyed, and their posterity condemned to toil upon the ruins of desolated nature.

It only remains to mention the manner in which he relieves the earth from this universal wreck, which would seem to be as difficult as even its first formation. "These great masses of earth falling into the abyss, drew down with them vast quantities also of air; and by dashing against each other, and breaking into small parts by the repeated violence of the shock, they at length left between them large cavities filled with nothing but air. These cavities naturally offered a bed to receive the influent waters; and in proportion as they filled, the face of the earth became once more visible. The higher parts of its broken surface, now become the tops of mountains, were the first that appeared; the plains soon after came forward,

and, at length, the whole globe was delivered from the waters, except the places in the lowest situations; so that the ocean and the seas are still a part of the ancient abyss that have not had a place to return. Islands and rocks are fragments of the earth's former crust; kingdoms and continents are larger masses of its broken substance; and all the inequalities that are to be found on the surface of the present earth, are owing to the accidental confusion into which both earth and waters were then thrown."

The next theorist was Woodward, who, in his Essay towards a Natural History of the Earth, which was only designed to precede a greater work, has endeavoured to give a more rational account of its appearances; and was, in fact, much better furnished for such an undertaking than any of his predecessors, being one of the most assiduous naturalists of his time. His little book, therefore, contains many important facts, relative to natural history, although his system may be weak and groundless.

He begins by asserting that all terrene substances are disposed in beds of various natures, lying horizontally one over the other, somewhat like the coats of an onion; that they are replete with shells, and other productions of the sea: these shells being found in the deepest cavities, and on the tops of the highest mountains. From these observations, which are warranted by experience, he proceeds to observe, that these shells and extraneous fossils are not productions of the earth, but are all actual remains of those animals which they are known to resemble; that all the beds of

the earth lie under each other, in the order of their specific gravity; and that they are disposed as if they had been left there by subsiding waters. All these assertions he affirms with much earnestness, although daily experience contradicts him in some of them; particularly we find layers of stone often over the lightest soils, and the softest earth under the hardest bodies. However, having taken it for granted, that all the layers of the earth are found in the order of their specific gravity, the lightest at the top, and the heaviest next the centre, he consequently asserts, that it will not improbably follow, that all the substances of which the earth is composed were, once, in an actual state of dissolution. This universal dissolution he takes to have happened at the time of the flood. He supposes that at that time a body of water, which was then in the centre of the earth, uniting with that which was found on the surface, so far separated the terrene parts as to mix all together in one fluid mass; the contents of which afterwards sinking according to their respective gravities, produced the present appearances of the earth. Being aware, however, of an objection that fossil substances are not found dissolved, he exempts them from this universal dissolution, and, for that purpose, endeavours to show that the parts of animals have a stronger cohesion than those of minerals; and that, while even the hardest rocks may be dissolved, bones and shells may still continue entire.

So much for Woodward; but of all the systems which were published respecting the earth's formation, that of Whiston was most applauded and most

opposed. Nor need we wonder; for being supported with all the parade of deep calculation, it awed the ignorant, and produced the approbation of such as would be thought otherwise, as it implied a knowledge of abstruse learning, to be even thought capable of comprehending what the writer aimed at. In fact, it is not easy to divest this theory of its mathematical garb; but those who have had leisure, have found the result of our philosopher's reasoning to be this: he supposes the earth to have been originally a comet; and he considers the history of the creation, as given us in scripture, to have its commencement just when it was, by the hand of the Creator, more regularly placed as a planet in our solar system. Before that time, he supposes it to have been a globe without beauty or proportion; a world in disorder; subject to all the vicissitudes which comets endure; some of which have been found, at different times, a thousand times hotter than melted iron; at others, a thousand times colder than ice. These alternations of heat and cold, continually melting and freezing the surface of the earth, he supposes to have produced, to a certain depth, a chaos entirely resembling that described by the poets, surrounding the solid contents of the earth, which still continued unchanged in the midst, making a great burning globe of more than two thousaud leagues in diameter. This surrounding chaos, however, was far from being solid: he resembles it to a dense though fluid atmosphere, composed of substances mingled, agitated, and shocked against each other; and in this disorder he describes the earth to have been just at the eve of creation.

But upon its orbit's being then changed, when it was more regularly wheeled round the sun, every thing took its proper place; every part of the surrounding fluid then fell into a situation, in proportion as it was light or heavy. The middle, or central part, which always remained unchanged, still continued so, retaining a part of that heat which it received in its primæval approaches towards the sun: which heat, he calculates, may continue for about six thousand years. Next to this fell the heavier parts of the chaotic atmosphere, which serve to sustain the lighter: but as in descending they could not entirely be separated from many watery parts, with which they were intimately mixed, they drew down a part of these also with them; and these could not mount again after the surface of the earth was consolidated: they, therefore, surrounded the heavy first descending parts, in the same manner as these surround the central globe. Thus the entire body of the earth is composed internally of a great burning globe: next which, is placed a heavy terrene substance, that encompasses it; round which also is circumfused a body of water. Upon this body of water, the crust of earth on which we inhabit is placed: so that, according to him, the globe is composed of a number of coats, or shells, one within the other, all of different densities. The body of the earth being thus formed, the air, which is the lightest substance of all, surrounded its surface; and the beams of the sun darting through, produced that light which, we are told, first obeyed the Creator's command.

being round, was now become oblate. In this universal wreck of nature Noah survived, by a variety of happy causes, to re-people the earth, and to give birth to a race of men slow in believing ill-imagined theories of the earth.

After so many theories of the earth, which have been published, applauded, answered, and forgotten, M. Buffon ventured to add one more to the number. This philosopher was, in every respect, better qualified than any of his predecessors for such an attempt, being furnished with more materials, having a brighter imagination to find new proofs, and a better style to clothe them in. However, if one so ill qualified, as I am, may judge, this seems the weakest part of this admirable work; and I could wish, that he had been content with giving us facts instead of systems; that, instead of being a reasoner, he had contented himself with being merely an historian.

He begins his system by making a distinction between the first part of it and the last; the one being founded only on conjecture, the other depending entirely upon actual observation. The latter part of his theory may, therefore, be true, though the former should be found erroneous.

The planets, says he, and the earth among the number, might have been formerly (he only offers this as conjecture) a part of the body of the sun, and adherent to its substance. In this situation, a comet falling in upon that great body might have given it such a shock, and so shaken its whole frame, that some of its particles might have been driven off like streaming sparkles from red hot iron; and each of these streams of fire.

small as they were in comparison of the sun, might have been large enough to have made an earth as great, nay many times greater, than ours. So that in this manner the planets, together with the globe which we inhabit, might have been driven off from the body of the sun by an impulsive force: in this manner also they would continue to recede from it for ever, were they not drawn back by its superior power of attraction; and thus, by the combination of the two motions, they are wheeled round in circles.

Being in this manner detached at a distance from the body of the sun, the planets, from having been at first globes of liquid fire, gradually became cool. The earth also having been impelled obliquely forward, received a rotatory motion upon its axis at the very instant of its formation; and this motion being greatest at the equator, the parts there acting against the force of gravity, they must have swollen out, and given the earth an oblate or flatted figure.

As to its internal substance, our globe having once belonged to the sun, it continues to be an uniform mass of melted matter, very probably vitrified in its primæval fusion. But its surface is very differently composed. Having been in the beginning heated to a degree equal to, if not greater, than what comets are found to sustain, like them it had an atmosphere of vapours floating round it, and whcih, cooling by degrees, condensed and subsided upon its surface. These vapours formed, according to their different densities, the earth, the water, and the air; the heavier

parts falling first, and the lighter remaining still suspended.

Thus far our philosopher is, at least, as much a system-maker as Whiston or Burnet; and, indeed, he fights his way with great perseverance and ingenuity through a thousand objections that naturally arise. Having, at last, got upon the earth, he supposes himself on firmer ground, and goes forward with greater security. Turning his attention to the present appearance of things upon this globe, he pronounces from the view that the whole earth was at first under water. This water he supposes to have been the lighter parts of its former evaporation, which, while the earthy particles sunk downwards by their natural gravity, floated on the surface, and covered it for a considerable space of time.

"The surface of the earth," says he,* "must have been in the beginning much less solid than it is at present; and, consequently, the same causes, which at this day produce but very slight changes, must then, upon so complying a substance, have had very considerable effects. We have no reason to doubt but that it was then covered with the waters of the sea; and that those waters were above the tops of our highest mountains, since, even in such elevated situations, we find shells and other marine productions in very great abundance. It appears also that the sea continued for a considerable time upon the face of the earth: for as these layers of shells are found so

* Théorie de la Terre, vol. i. p. 111.

very frequent at such great depths, and in such prodigious quantities, it seems impossible for such numbers to have been supported all alive at one time; so that they must have been brought there by successive depositions. These shells also are found in the bodies of the hardest rocks, where they could not have been deposited, all at once, at the time of the deluge, or at any such instant revolution; since that would be to suppose, that all the rocks in which they are found were, at that instant, in a state of dissolution, which would be absurd to assert. The sea, therefore, deposited them wheresoever they are now to be found, and that by slow and successive degrees.

It will appear, also, that the sea covered the whole earth, from the appearance of its layers, which lying regularly one above the other, seem all to resemble the sediment formed at different times by the ocean. Hence, by the irregular force of its waves, and its currents driving the bottom into sand-banks, mountains must have been gradually formed within this universal covering of waters; and these successively raising their heads above its surface, must, in time, have formed the highest ridges of mountains upon land, together with continents, islands, and low grounds, all in their turns. This opinion will receive additional weight by considering, that in those parts of the earth where the power of the ocean is greatest, the inequalities on the surface of the earth are highest: the ocean's power is greatest at the equator, where its winds and tides are most constant; and, in fact, the mountains

at the equator are found to be higher than in any other part of the world. The sea, therefore, has produced the principal changes in our earth: rivers, volcanoes, earthquakes, storms, and rain, having made but slight alterations, and only such as have affected the globe to very inconsiderable depths."

This is but a very slight sketch of M. Buffon's Theory of the Earth; a theory which he has much more powerfully supported, than happily invented; and it would be needless to take up the reader's time from the pursuit of truth in the discussion of plausibilities. In fact, a thousand questions might be asked this most ingenious philosopher, which he would not find it easy to answer; but such is the lot of humanity, that a single Goth can in one day destroy the fabric which Cæsars were employed an age in erecting. We might ask how mountains, which are composed of the most compact and ponderous substances, should be the first whose parts the sea began to remove? We might ask, how fossil-wood is found deeper even than shells? which argues, that trees grew upon the places he supposes once to have been covered with the ocean. But we hope this excellent man is better employed than to think of gratifying the petulance of incredulity by answering endless objections.

[Other theories have since been formed, endeavouring to throw light on this most intricate subject; the principal of which are those of Dr. Hutton and Mr. Whitehurst.

Dr. Hutton supposes the earth to have existed

from eternity, and that there is to be found in it no vestige of a beginning, no prospect of an end. He regards it as a fabric erected in wisdom, the purpose of whose creation is that it may be a habitation for living animals.

He considers it as composed of three principal parts, properly adapted together: a solid or terrestrial part, supported by a central body; an aqueous part, reduced to a spherical form by gravitation, and made oblate by the earth's centrifugal force; and an atmosphere, surrounding the whole, evidently necessary for innumerable purposes of life and vegetation. The powers by which it is suspended he supposes to be the gravitating and projecting forces by which the planets are guided; the influence of light and heat, cold and condensation, and electricity and magnetism.

The component parts of the world he supposes to be in an alternate state of production and decay; and that, from a view of the present construction and operations of nature, we may easily understand what has formerly passed in the original formation of the globe; and what will eventually succeed in future ages.

The solid parts of the earth, he thinks, were formed at the bottom of the sea; and that these have been made prominent, either by the elevation of these consolidated masses above the level on which they were formed, or by lowering the level of the sea. These materials, at first soft and plastic, he considers to have been consolidated by subterraneous heat and fusion, produc-

ing, by their different combinations, all the different minerals and solid parts of the earth.

The strata formed at the bottom of the ocean are necessarily horizontal in their position, or nearly so; and continuous in their horizontal direction and extent. They may change and gradually assume the nature of each other, so far as concerns the materials of which they are formed; but there cannot be any change, fracture, or displacement naturally in the body of a stratum; but if these strata are cemented by the heat of fusion, and ejected with an expansive force acting below, we may expect to find every species of fracture, dislocation, and contortion in those bodies, and every degree of departure from a horizontal towards a vertical position. The strata of the globe are actually found in every possible position; for, from horizontal they are frequently found vertical; from continuous they are broken and separated in every possible direction; and from a plane they are bent and doubled. It is impossible they could have been formed by the known laws of nature, in their present state and position. And here the apparent irregularity and disorder of the mineral regions are as instructive, with regard to what had been transacted in a former period of time, as the order and regularity of these same regions are conclusive, in the relation to the place, in which a former state of things had produced that which, in its changed state, we now perceive.

We are now to conclude that the land on which

we dwell had been elevated from a lower situation, by the same agent which had been employed in consolidating the strata, in giving them stability, and preparing them for the purpose of the living world This agent is matter actuated by extreme heat, and expanded with amazing force. If this has been the case, it will be reasonable to expect that some of the expanded matter might be found condensed in the bodies which have been heated by that igneous vapour; and that matter, foreign to the strata, may have been thus introduced into the fractures and separations of those indurated masses. We have but to open our eyes to be convinced of this truth: look into the sources of our mineral treasures; ask the miner from whence the metal has come into his vein? not from the earth or air above; not from the strata which the vein traverses.—There is but one place from whence these minerals may have come, and that is the bowels of the earth; the place of power and expansion; the place from whence must have proceeded that intense heat, by which loose materials have been consolidated into rocks, as well as that enormous force, by which the regular strata have been broken and displaced.

Our land has two extremities,—the tops of the mountains on one hand, and the sea-shore on the other. It is the intermediate space between these two, that forms the habitation of man and animals. While there is a sea, shores, and high ground, there is that which is required in the system of the world; take these away, and there would remain an aqueous globe, in which the

world would perish. But in the natural operation of the world, it is necessary that the present land should be worn away and wasted, exactly in proportion as new land shall appear; or, conversely, that an equal portion of new land should always be produced as the old is made to disappear. In this manner a due proportion of land and water is always preserved upon the surface of the globe, for the purpose of a habitable world.

Mr. Whitehurst supposes, with Linnæus, that the globe we now inhabit was originally in a state of fluidity; and that, not owing to any dissolvent principle or subsequent solution, but to the first assemblage of its component parts. Whence it is presumed, that the earth had a beginning, and has not existed from eternity; though the precise number of ages it has existed, have not yet been actually determined. This he endeavours to prove by its oblate spheroidal form, which may easily be conceived of a fluid globe, but not of a solid one. The fluidity of the earth, says he, and the infinite divisibility of matter, evidently show that the component parts of air, earth, water, &c. were uniformly blended together, none being heavier or lighter than another; whereby they composed an uniform mass or pulp, of equal consistence in every part, from its surface to its centre: consequently the new formed globe, in its chaotic state, was unfit for animal or vegetable life, and its inhabitants were not created till the earth was become suitable to the nature of their existence. The component parts of this chaos were subterraneous, or endowed

with peculiar laws of elective attraction; whereby similar bodies are disposed to unite and form select bodies of various denominations, as air, water, earth, &c.; by means of which principles, the chaos was progressively formed into a habitable world.

The atmosphere, sea, and land, being thus formed for the reception of the animal and vegetable kingdoms, in successive periods of time, we have now to consider the order in which they were severally created. First, since it appears that the ocean became perfectly pure and fit for animal life, before the primitive islands were formed, therefore we have endeavoured to prove, from a series of undeniable facts, that marine animals were first formed; and being extremely prolific, they increased and multiplied so exceedingly, as to replenish the sea from pole to pole. The ocean being thus stocked with inhabitants, prior to the formation of the primitive islands, many of them became enveloped and buried in the mud, by the continual action of the tides; particularly all the species of shell-fish, which are least able to defend themselves from such interments. Therefore, since the remains of marine animals are imbedded at various depths in the earth, from one to that of several thousand feet, and this in all parts of the world hitherto explored, they bear sufficient testimony that these marine bodies were thus entombed at successive periods of time; and, likewise, that they were created prior to the primitive islands, and consequently prior to any terrestrial animals. It may be needless further to observe, that these beds of

marine shells plainly evince that they were generated, lived, and died, in the very beds wherein they were found, and were not brought from distant regions by a flood or floods of water; consequently such beds were originally the bottom of the ocean.

[To these, as to all other human theories, material and unconquerable objections might be made; but our business here is not discussion or refutation, but merely to lay before our readers the reasonings and inductions of those who have formed them.]

CHAP. V.

Of Fossil-shells, and other extraneous Fossils.

WE may affirm of M. Buffon, that which has been said of the chymists of old; though he may have failed in attaining his principal aim, of establishing a theory, yet he has brought together such a multitude of facts, relative to the history of the earth, and the nature of its fossil productions, that curiosity finds ample compensation even while it feels the want of conviction.

Before, therefore, I enter upon the description of those parts of the earth, which seem more naturally to fall within the subject, it will not be improper to give a short history of those animal productions that are found in such quantities, either upon its surface, or at different depths below it. They demand our curiosity, and, indeed,

there is nothing in natural history that has afforded more scope for doubt, conjecture, and speculation. Whatever depths of the earth we examine, or at whatever distance within land we seek, we most commonly find a number of fossil-shells, which being compared with others from the sea, of known kinds, are found to be exactly of a similar shape and nature.* They are found at the very bottom of quarries and mines, in the retired and inward parts of the most firm and solid rocks, upon the tops of even the highest hills and mountains, as well as in the vallies and plains; and this not in one country alone, but in all places where there is any digging for marble, chalk, or any other terrestrial matters, that are so compact as to fence off the external injuries of the air, and thus preserve these shells from decay.

These marine substances, so commonly diffused, and so generally to be met with, were for a long time considered by philosophers as productions, not of the sea, but of the earth. "As we find that spars," said they, "always shoot into peculiar shapes, so these seeming snails, cockles, and muscle-shells, are only sportive forms that nature assumes amongst others of its mineral varieties: they have the shape of fish, indeed, but they have always been terrestrial substances." †

With this plausible solution mankind were for a long time content; but, upon closer inquiry,

* Woodward's Essay towards a Natural History, p. 16.

† Lowthorp's Abridgment, Phil. Trans. vol. ii. p. 426.

they were obliged to alter their opinion. It was found that these shells had, in every respect, the properties of animal and not of mineral nature.

They were found exactly of the same weight with their fellow shells upon shore. They answered all the chymical trials in the same manner as sea shells do. Their parts, when dissolved, had the same appearance to view, the same smell and taste. They had the same effects in medicine when inwardly administered; and, in a word, were so exactly conformable to marine bodies, that they had all the accidental concretions growing to them, (such as pearls, corals, and smaller shells) which are found in shells just gathered on the shore. They were, therefore, from these considerations, given back to the sea; but the wonder was, how to account for their coming so far from their own natural element upon land.*

As this naturally gave rise to many conjectures, it is not to be wondered that some among them have been very extraordinary. An Italian, quoted by M. Buffon, supposes them to have been deposited in the earth at the time of the crusades, by the pilgrims who returned from Jerusalem: who, gathering them upon the sea-shore, in their return, carried them to their different places of habitation. But this conjecturer seems to have but a very inadequate idea of their numbers. At Touraine, in France, more than an hundred miles from the sea, there is a plain of about nine leagues long, and as many broad, from whence the peasants of the country supply themselves with marl

* Woodward, p. 43.

for manuring their lands. They seldom dig deeper than twenty feet, and the whole plain is composed of the same materials, which are shells of various kinds, without the smallest portion of earth between them. Here then is a large space, in which are deposited millions of tons of shells, that pilgrims could not have collected, though their whole employment had been nothing else. England is furnished with its beds, which though not quite so extensive, yet are equally wonderful. "* Near Reading, in Berkshire, for many succeeding generations, a continued body of oyster-shells has been found through the whole circumference of five or six acres of ground. The foundation of these shells is a hard rocky chalk; and above this chalk, the oyster-shells lie in a bed of green sand, upon a level, as nigh as can possibly be judged, and about two feet thickness." These shells are in their natural state, but they were found also petrified, and almost in equal abundance† in all the Alpine rocks, in the Pyrenees, on the hills of France, England, and Flanders. Even in all quarries from whence marble is dug, if the rocks be split perpendicularly downwards, petrified shells, and other marine substances, will be plainly discerned.

"About a quarter of a mile from the river Medway,‡ in the county of Kent, after the taking off the coping of a piece of ground there, the workmen came to a blue marble, which continued for three feet and a half deep, or more, and then beneath appeared a hard floor, or pavement, com-

* Phil. Trans. vol. ii. p. 427. † Buffon, vol. i. p. 407.
‡ Phil. Trans. p. 426.

posed of petrified shells crowded closely together. This layer was about an inch deep, and several yards over; and it could be walked upon as upon a beach. These stones, of which it was composed, (the describer supposes them to have always been stones) were either wreathed as snails, or bivalvular like cockles. The wreathed kinds were about the size of a hazle nut, and were filled with a stony substance of the colour of marl; and they themselves, also, till they were washed, were of the same colour; but when cleaned they appeared of the colour of bezoar, and of the same polish. After boiling in water they became whitish, and left a chalkiness upon the fingers."

In several parts of Asia and Africa, travellers have observed these shells in great abundance. In the mountains of Castravan, which lie above the city Barut, they quarry out a white stone, every part of which contains petrified fishes in great numbers, and of surprising diversity. They also seem to continue in such preservation, that their fins, scales, and all the minutest distinctions of their make, can be perfectly discerned.*

From all these instances we may conclude, that fossils are very numerous; and, indeed, independent of their situation, they afford no small entertainment to observe them as preserved in the cabinets of the curious. The varieties of their kinds are astonishing. Most of the sea shells which are known, and many others to which we are entirely strangers, are to be seen either in their natural state, or in various degrees of petrifaction.†

* Buffon, vol. i. p. 408. † Hill, p. 646.

In the place of some we have mere spar, or stone, exactly expressing all the lineaments of animals, as having been wholly formed from them. For it has happened that the shells dissolving by very slow degrees, and the matter having nicely and exactly filled all the cavities within, this matter, after the shells have perished, has preserved exactly and regularly the whole print of their internal surface. Of these there are various kinds found in our pits; many of them resembling those of our own shores; and many others that are only to be found on the coasts of other countries. There are some shells resembling those that are never stranded upon our coasts,* but always remain in the deep: † and many more there are which we can assimilate with no shells known amongst us. But we find not only shells in our pits, but also fishes and corals in great abundance; together with almost every sort of marine production.

It is extraordinary enough, however, that the common red coral, though so very frequent at sea, is scarcely seen in the fossil world; nor is there any account of its having ever been met with. But to compensate for this, there are all the kinds of the white coral now known; and many other kinds of that substance with which we are unacquainted. Of animals there are various parts: the vertebræ of whales, and the mouths of lesser fishes; these, with teeth also of various kinds, are found in the cabinets of the curious; where they receive long Greek names, which it is neither the intention nor the province of this work to enumerate. Indeed,

* Littorales. † Pelagii.

few readers would think themselves much improved, should I proceed with enumerating the various classes of the Conicthyodontes, Polyleptoginglimi, or the Orthoceratites. These names, which mean no great matter when they are explained, may serve to guide in the furnishing a cabinet; but they are of very little service in furnishing the page of instructive history.

From all these instances we see in what abundance petrifactions are to be found: and, indeed, M. Buffon, to whose accounts we have added some, has not been sparing in the variety of his quotations, concerning the places where they are mostly to be found. However, I am surprised that he should have omitted the mention of one, which, in some measure, more than any of the rest, would have served to strengthen his theory. We are informed, by almost every traveller,* that has described the pyramids of Egypt, that one of them is entirely built of a kind of free-stone, in which these petrified shells are found in great abundance. This being the case, it may be conjectured, as we have accounts of these pyramids among the earliest records of mankind, and of their being built so long before the age of Herodotus, who lived but fifteen hundred years after the flood, that even the Egyptian priests could tell neither the time nor the cause of their erection; I say it may be conjectured that they were erected but a short time after the flood. It is not very likely, therefore, that the marine substances found in one of them, had time to be formed into a part of the solid stone,

* Hasselquist, Sandys.

either during the deluge, or immediately after it; and, consequently, their petrifaction must have been before that period. And this is the opinion M. Buffon has so strenuously endeavoured to maintain; having given specious reasons to prove that such shells were laid in the beds where they are now found, not only before the deluge, but even antecedent to the formation of man, at the time when the whole earth, as he supposes, was buried beneath a covering of waters.

But while there are many reasons to persuade us that these extraneous fossils have been deposited by the sea, there is one fact that will abundantly serve to convince us that the earth was habitable, if not inhabited, before these marine substances came to be thus deposited; for we find fossil-trees, which no doubt once grew upon the earth, as deep, and as much in the body of solid rocks, as these shells are found to be. Some of these fallen trees also have lain at least as long, if not longer, in the earth, than the shells, as they have been found sunk deep in a marly substance, composed of decayed shells, and other marine productions. M. Buffon has proved that fossil-shells could not have been deposited in such quantities all at once by the flood; and I think, from the above instance, it is pretty plain, that howsoever they were deposited, the earth was covered with trees before their deposition; and, consequently, that the sea could not have made a very permanent stay. How then shall we account for these extraordinary appearances in nature? A suspension of all assent is certainly the first, although the most mortifying

conduct. For my own part, were I to offer a conjecture, and all that has been said upon this subject is but conjecture, instead of supposing them to be the remains of animals belonging to the sea, I would consider them rather as bred in the numerous fresh-water lakes that, in primæval times, covered the face of uncultivated nature. Some of these shells we know to belong to fresh waters: some can be assimilated to none of the marine shells now known;* why, therefore, may we not as well ascribe the production of all to fresh waters, where we do not find them, as we do that of the latter, to the sea only, where we never find them? We know that lakes, and lands also, have produced animals that are now no longer existing; why, therefore, might not these fossil productions be among the number? I grant that this is making a very harsh supposition; but I cannot avoid thinking, that it is not attended with so many embarrassments as some of the former; and that it is much easier to believe that these shells were bred in fresh water, than that the sea had for a long time covered the tops of the highest mountains.†

* Hill's Fossils, p. 641.

[† Though it would be absurd to attempt explaining all the difficulties of this natural phænomenon, yet it appears sufficiently accounted for by the operation of the general deluge. In this vast conflict of sea and land, the earth was softened by an incessant rain of six weeks duration, and the sea rising on all sides, poured in upon every part of its surface, all its light and moveable contents, with an impetuosity unmeasurable by any modern parallel. Great numbers of these shells, inhabiting near the sea coasts in their various stages of growth, would naturally

CHAP. VI.

Of the internal Structure of the Earth.

HAVING, in some measure, got free from the regions of conjecture, let us now proceed to a de-

change their habitations, and be impelled by this force to the tops of mountains and other elevated places. The flood, according to Scripture, was forty days in arriving to its full height, remained stationary five months, and it was not till near the end of the eleventh month that the tops of the trees became visible above the surface of the water. Here was time for the spawn and smaller ones to grow to maturity: and as they possess but little locomotive power, and as the water was slow and gradual in its retreat, there must have remained behind immense masses distributed on various parts of the earth. By the continuance of such a body of water so long a time upon the earth, it must have become soft and easily penetrable. These helpless animals, therefore, brought with the ocean at its first eruption, were probably buried in the mud, and by the gradual mouldering of the softer parts of the earth, were sometimes covered to a great depth. Here, in many places, they may have been consolidated by petrifaction and the growth of calcareous matter over them.

At the time when these shells were deposited, the same wreck of nature would overthrow and leave with them old and decayed trees, and different parts of the vegetable creation. A few, likewise, of the larger inhabitants of the ocean, unable to make their escape, would be left behind, and partake of the same general ruin. In the mountain of Canne, half a league from Maestrict, were found the remains of a crocodile, well preserved, in a stratum of sand-stone: the remains of another were also found in a stratum of stone at Blenheim.

The question, likewise, why so few or no corals are to be found on land, is upon these principles easily answered. Coral rocks require a great length of time for their production and accumulation: they are strongly fixed to the places where they grow; and cannot, therefore, without a force which must be more than adequate to the cause assigned, be removed from their situation, and placed on land.]

scription of the earth as we find it by examination, and observe its internal composition, as far as it has been the subject of experience, or exposed to human inquiry. These inquiries, indeed, have been carried but to a very little depth below its surface, and even in that disquisition men have been conducted more by motives of avarice than of curiosity. The deepest mine, which is that at Cotteberg in Hungary,* reaches not more than three thousand feet deep; but what proportion does that bear to the depth of the terrestrial globe, down to the centre, which is above four thousand miles? All, therefore, that has been said of the earth, to a deeper degree, is merely fabulous or conjectural: we may suppose with one, that it is a globe of glass;† with another, a sphere of heated iron;‡ with a third, a great mass of waters;§ and with a fourth, one dreadful volcano:|| but let us, at the same time, show our consciousness, that all these are but suppositions.

Upon examining the earth, where it has been opened to any depth, the first thing that occurs, is the different layers or beds of which it is composed; these all lying horizontally one over the other, like the leaves of a book, and each of them composed of materials that increase in weight in proportion as they lie deeper. This is, in general, the disposition of the different materials where the earth seems to have remained unmolested; but this order is frequently inverted; and we cannot tell whether from its original formation, or from

* Boyle, vol. iii. p. 240. † Buffon.
‡ Whiston. § Burnet. || Kircher.

accidental causes. Of different substances, thus disposed, the far greatest part of our globe consists, from its surface downwards to the greatest depths we ever dig or mine.*

The first layer, most commonly found at the surface, is that light coat of blackish mould, which is called by some garden earth. With this the earth is every where invested, unless it be washed off by rains, or removed by some other external violence. This seems to have been formed from animal and vegetable bodies decaying, and thus turning into its substance. It also serves again as a store-house, from whence animal and vegetable nature are renewed; and thus are all vital blessings continued with unceasing circulation. This earth, however, is not to be supposed entirely pure, but is mixed with much stony and gravelly matter, from the layers lying immediately beneath it. It generally happens, that the soil is fertile in proportion to the quantity that this putrified mould bears to the gravelly mixture; and as the former predominates, so far is the vegetation upon it more luxuriant. It is this external covering that supplies man with all the true riches he enjoys. He may bring up gold and jewels from greater depths; but they are merely the toys of a capricious being, things upon which he has placed an imaginary value, and for which fools alone part with the more substantial blessings of life. It is this earth, says Pliny,† that, like a kind mother, receives us at our birth, and sustains us

* Woodward, p. 9.

† Plin. Hist. Nat. lib. 2. cap. 63.

when born. It is this alone, of all the elements around us, that is never found an enemy to man. The body of waters deluge him with rains, oppress him with hail, and drown him with inundations. The air rushes in storms, prepares the tempest, or lights up the volcano; but the earth, gentle and indulgent, ever subservient to the wants of man, spreads his walks with flowers, and his table with plenty; returns with interest every good committed to her care; and, though she produces the poison, she still supplies the antidote; though constantly teazed more to furnish the luxuries of man than his necessities, yet, even to the last, she continues her kind indulgence, and, when life is over, she piously covers his remains in her bosom.

This external and fruitful layer which covers the earth, is, as was said, in a state of continual change. Vegetables, which are naturally fixed and rooted to the same place, receive their adventitious nourishment from the surrounding earth and water: animals, which change from place to place, are supported by these, or by each other. Both, however, having for a time enjoyed a life adapted to their nature, give back to the earth those spoils, which they had borrowed for a very short space, yet still to be quickened again into fresh existence. But the deposits they make are of very dissimilar kinds, and the earth is very differently enriched by their continuance. Those countries that have for a long time supported men and other animals, having been observed to become every day more barren; while, on the contrary, those desolate places, in which vege-

tables only are abundantly produced, are known to be possessed of amazing fertility. * "In regions which are uninhabited," says M. Buffon, "where the forests are not cut down, and where animals do not feed upon the plants, the bed of vegetable earth is constantly increasing. In all woods, and even in those often cut, there is a layer of earth of six or eight inches thick, which has been formed by the leaves, branches and bark, which fall and rot upon the ground. I have frequently observed, on a Roman way which crosses Burgundy for a long extent, that there is a bed of black earth, of more than a foot thick, gathered over the stony pavement, on which several trees, of a very considerable size, are supported. This I have found to be nothing else than an earth formed by decayed leaves and branches, which have been converted by time into a black soil. Now, as vegetables draw much more of their nourishment from the air and water than they do from the earth, it must follow, that in rotting upon the ground, they must give more to the soil than they have taken from it. Hence, therefore, in woods kept a long time without cutting, the soil below increases to a considerable depth; and such we actually find the soil in those American wilds where the forests have been undisturbed for ages But it is otherwise where men and animals have long subsisted; for as they make a considerable consumption of wood and plants, both for firing and other uses, they take more from the earth

* Buffon, vol. i. p. 353.

than they return to it: it follows, therefore, that the bed of vegetable earth, in an inhabited country, must be always diminishing; and must, at length, resemble the soil of Arabia Petrea, and other provinces of the East, which having been long inhabited, are now become plains of salt and sand;—the fixed salt always remaining, while the other volatile parts have flown away."

If from this external surface we descend deeper, and view the earth cut perpendicularly downwards, either in the banks of great rivers, or steepy sea-shores, or, going still deeper, if we observe it in quarries or mines, we shall find its layers regularly disposed in their proper order. We must not expect, however, to find them of the same kind or thickness in every place, as they differ in different soils and situations. Sometimes marl is seen to be over sand, and sometimes under it. The most common disposition is, that under the first earth is found gravel or sand, then clay or marle, then chalk or coal, marbles, ores, sands, gravels; and thus an alternation of these substances, each growing more dense as it sinks deeper. The clay, for instance, found at the depth of a hundred feet, is usually more heavy than that found not far from the surface. In a well which was dug at Amsterdam, to the depth of two hundred and thirty feet, the following substances were found in succession:* seven feet of vegetable earth, nine of turf, nine of soft clay, eight of sand, four of earth, ten of clay, four of earth, ten of sand, two of clay, four of white

* Varenius, as quoted by M. Buffon, p. 358.

sand, one of soft earth, fourteen of sand, eight of clay mixed with sand, four of sea-sand mixed with shells, then a hundred and two feet of soft clay, and then thirty-one feet of sand.

In a well dug at Marly, to the depth of a hundred feet, M. Buffon gives us a still more exact enumeration of its layers of earth. Thirteen of a reddish gravel, two of gravel mingled with a vitrifiable sand, three of mud or slime, two of marl, four of marly stone, five of marl in dust mixed with vitrifiable sand, six of very fine vitrifiable sand, three of earthy marl, three of hard marl, one of gravel, one of eglantine, a stone of the hardness and grain of marble, one of gravelly marl, one of stony marl, one of a coarser kind of stony marl, two of a coarser kind still, one of vitrifiable sand mixed with fossil-shells, two of fine gravel, three of stony marl, one of coarse powdered marl, one of stone calcinable like marble, three of grey sand, two of white sand, one of red sand streaked with white, eight of grey sand with shells, three of very fine sand, three of a hard grey stone, four of red sand streaked with white, three of white sand, and fifteen of reddish vitrifiable sand.

In this manner, the earth is every where found in beds over beds; and, what is still remarkable, each of them, as far as it extends, always maintains exactly the same thickness. It is found, also, that, as we proceed to considerable depths, every layer grows thicker. Thus, in the adduced instances, we might have observed, that the last layer was fifteen feet thick, while most of the others were not above eight; and this might have

gone much deeper, for aught we can tell, as before they got through it the workmen ceased digging.

These layers are sometimes very extensive, and often are found to cover a space of some leagues in circumference. But it must not be supposed that they are uniformly continued over the whole globe without any interruption; on the contrary, they are ever, at small intervals, cracked through as it were by perpendicular fissures; the earth resembling, in this respect, the muddy bottom of a pond, from whence the water has been dried off by the sun, and thus gaping in several chinks, which descend in a direction perpendicular to its surface. These fissures are many times found empty, but oftener closed up with adventitious substances, that the rain, or some other accidental causes, have conveyed to fill their cavities. Their openings are not less different than their contents, some being not above half an inch wide, some a foot, and some several hundred yards asunder; which last form those dreadful chasms that are to be found in the Alps, at the edge of which the traveller stands, dreading to look down at the immeasurable gulph below. These amazing clefts are well known to such as have passed these mountains, where a chasm frequently presents itself several hundred feet deep, and as many over, at the edge of which the way lies. It often happens, also, that the road leads along the bottom, and then the spectator observes on each side frightful precipices several hundred yards above him; the sides of which correspond

so exactly with each other, that they evidently seem torn asunder.

But these chasms, to be found in the Alps, are nothing to what Ovalle tells us are to be seen in the Andes. These amazing mountains, in comparison of which the former are but little hills, have their fissures in proportion to their greatness. In some places they are a mile wide, and deep in proportion; and there are some others, that, running under ground, in extent resemble a province.

Of this kind also is that cavern called Elden-hole, in Derbyshire; which, Dr. Plot tells us, was sounded by a line of eight and twenty hundred feet, without finding the bottom, or meeting with water; and yet the mouth, at the top, is not above forty yards over.* This immeasurable cavern runs perpendicularly downward; and the sides of it seem to tally so plainly as to show that they once were united. Those who come to visit the place, generally procure stones to be thrown into its mouth; and these are heard for several minutes, falling and striking against the sides of the cavern, producing a sound that resembles distant thunder, dying away as the stone goes deeper.

Of this kind, also, is that dreadful cavern described by Ælian; his account of which the reader may not have met with.† "In the country of the Arrian Indians, is to be seen an amazing chasm, which is called, The Gulph of Pluto. The depth and the recesses of this horrid place,

* Phil. Trans. vol. ii. p. 370.

† Æliani Var. Hist. lib. xvi. cap. 16.

are as extensive as they are unknown. Neither the natives, nor the curious who visit it, are able to tell how it was first made, or to what depths it descends. The Indians continually drive thither great multitudes of animals, more than three thousand at a time, of different kinds, sheep, horses, and goats; and, with an absurd superstition, force them into the cavity, from whence they never return. Their several sounds, however, are heard as they descend; the bleating of sheep, the lowing of oxen, and the neighing of horses, issuing up to the mouth of the cavern. Nor do these sounds cease, as the place is continually furnished with a fresh supply."

There are many more of these dreadful perpendicular fissures in different parts of the earth; with accounts of which Kircher, Gaffarellus, and others, who have given histories of the wonders of the subterranean world, abundantly supply us. The generality of readers, however, will consider them with less astonishment, when they are informed of their being common all over the earth: that in every field, in every quarry, these perpendicular fissures are to be found; either still gaping, or filled with matter that has accidentally closed their interstices. The inattentive spectator neglects the inquiry, but their being common is partly the cause that excites the philosopher's attention to them: the irregularities of nature he is often content to let pass unexamined; but when a constant and a common appearance presents itself, every return of the object is a fresh call to his curiosity; and the chink in the next quarry becomes as great a matter of wonder as the chasm

in Elden-hole. Philosophers have long, therefore, endeavoured to find out the cause of these perpendicular fissures, which our own countrymen, Woodward and Ray, were the first that found to be so common and universal. M. Buffon supposes them to be cracks made by the sun, in drying up the earth immediately after its immersion from the deep. The heat of the sun is very probably a principal cause; but it is not right to ascribe to one only, what we find may be the result of many. Earthquakes, severe frosts, bursting waters, and storms tearing up the roots of trees, have, in our own times, produced them; and to this variety of causes we must, at present, be content to assign those that have happened before we had opportunities for observation.

CHAP. VII.

Of Caves and Subterraneous Passages that sink, but not perpendicularly, into the Earth.

IN surveying the subterranean wonders of the globe, besides those fissures that descend perpendicularly, we frequently find others that descend but a little way, and then spread themselves often to a great extent below the surface. Many of these caverns, it must be confessed, may be the production of art and human industry; retreats made to protect the oppressed, or shelter the spoiler. The famous labyrinth of Candia, for instance, is supposed to be entirely the work of

art. M. Tournefort assures us, that it bears the impression of human industry, and that great pains have been bestowed upon its formation. The stone-quarry of Maestricht is evidently made by labour: carts enter at its mouth, and load within, then return and discharge their freight into boats that lie on the brink of the river Maese. This quarry is so large, that forty thousand people may take shelter in it: and it in general serves for this purpose, when armies march that way; becoming then an impregnable retreat to the people that live thereabout. Nothing can be more beautiful than this cavern, when lighted up with torches; for there are thousands of square pillars, in large level walks, about twenty feet high; and all wrought with much neatness and regularity. In this vast grotto there is very little rubbish; which shows both the goodness of the stone, and the carefulness of the workmen. To add to its beauty, there also are, in various parts of it, little pools of water, for the convenience of the men and cattle. It is remarkable, also, that no droppings are seen to fall from the roof, nor are the walks any way wet under foot, except in cases of great rains, where the water gets in by the air-shafts. The salt-mines in Poland are still more spacious than these. Some of the catacombs, both in Egypt and Italy, are said to be very extensive. But no part of the world has a greater number of artificial caverns than Spain, which were made to serve as retreats to the Christians, against the fury of the Moors, when the latter conquered that country. However, an account of the works of art does not properly be-

long to a natural history. It will be sufficient to observe, that though caverns be found in every country, far the greatest part of them have been fashioned by the hand of nature only. Their size is found beyond the power of man to have effected; and their forms but ill adapted to the conveniences of a human habitation. In some places, indeed, we find mankind still make use of them as houses; particularly in those countries where the climate is very severe;* but in general they are deserted by every race of meaner animals, except the bat: these nocturnal solitary creatures are usually the only inhabitants; and these only in such whose descent is sloping, or, at least, not directly perpendicular.

There is scarcely a country in the world without its natural caverns; and many new ones are discovered every day. Of those in England, Oakey-hole, the Devil's-hole, and Penpark-hole, have been often described. The former, which lies on the south side of Mendip-hills,† within a mile of the town of Wells, is much resorted to by travellers. To conceive a just idea of this, we must imagine a precipice of more than a hundred yards high, on the side of a mountain which shelves away a mile above it. In this is an opening not very large, into which you enter, going along upon a rocky uneven pavement, sometimes ascending, and sometimes descending. The roof of it, as you advance, grows higher; and, in some places, is fifty feet from the floor. In some places, however, it is so low that a man must stoop to pass.

* Phil. Trans. vol. ii. p. 368. † Ibid.

It extends itself, in length, about two hundred yards; and from every part of the roof, and the floor, there are formed sparry concretions of various figures, that by strong imaginations have been likened to men, lions, and organs. At the farthest part of this cavern rises a stream of water, well stored with fish, large enough to turn a mill, and which discharges itself near the entrance.

Penpark-hole, in Gloucestershire, is almost as remarkable as the former. Captain Sturmey descended into this by a rope, twenty-five fathoms perpendicular, and at the bottom found a very large vault in the shape of a horse-shoe. The floors consisted of a kind of white stone enamelled with lead ore, and the pendant rocks were glazed with spar. Walking forward on this stony pavement, for some time, he came to a great river, twenty fathoms broad, and eight fathoms deep; and having been informed that it ebbed and flowed with the sea, he remained in his gloomy abode for five hours, to make an exact observation. He did not find, however, any alteration whatsoever in its appearance. But his curiosity was ill requited; for it cost this unfortunate gentleman his life: immediately after his return, he was seized with an unusual and violent head-ache, which threw him into a fever, of which he died soon after.

But of all the subterraneous caverns now known, the grotto of Antiparos is the most remarkable, as well for its extent, as for the beauty of its sparry incrustations. This celebrated cavern was first discovered by one Magni, an Italian traveller, about a hundred years ago, at Antiparos,

an inconsiderable island of the Archipelago.* The account he gives of it is long and inflated, but upon the whole amusing. "Having been informed," says he, "by the natives of Paros, that in the little island of Antiparos, which lies about two miles from the former, of a gigantic statue, that was to be seen at the mouth of a cavern in that place, it was resolved that we (the French consul and himself) should pay it a visit. In pursuance of this resolution, after we had landed on the island, and walked about four miles through the midst of beautiful plains, and sloping woodlands, we at length came to a little hill, on the side of which yawned a most horrid cavern, that with its gloom at first struck us with terror, and almost repressed curiosity. Recovering the first surprise, however, we entered boldly; and had not proceeded above twenty paces, when the supposed statue of the giant presented itself to our view. We quickly perceived, that what the ignorant natives had been terrified at as a giant, was nothing more than a sparry concretion, formed by the water dropping from the roof of the cave, and by degrees hardening into a figure that their fears had formed into a monster. Incited by this extraordinary appearance, we were induced to proceed still farther, in quest of new adventures, in this subterranean abode. As we proceeded, new wonders offered themselves; the spars, formed into trees and shrubs, presented a kind of petrified

* Kircher Mund. Subt. 112. I have translated a part of Kircher's description, rather than Tournefort's, as the latter was written to support an hypothesis.

grove; some white, some green; and all receding in due perspective. They struck us with the more amazement, as we knew them to be mere productions of Nature, who hitherto in solitude, had, in her playful moments, dressed the scene, as if for her own amusement.

"But we had as yet seen but a few of the wonders of the place; and were introduced only into the portico of this amazing temple. In one corner of this half-illuminated recess, there appeared an opening of about three feet wide, which seemed to lead to a place totally dark, and that one of the natives assured us contained nothing more than a reservoir of water. Upon this we tried, by throwing down some stones, which rumbling along the sides of the descent for some time, the sound seemed at last quashed in a bed of water. In order, however, to be more certain, we sent in a Levantine mariner, who, by the promise of a good reward, with a flambeau in his hand, ventured into this narrow aperture. After continuing within it for about a quarter of an hour, he returned, carrying some beautiful pieces of white spar in his hand, which art could neither imitate nor equal. Upon being informed by him that the place was full of these beautiful incrustations, I ventured in once more with him, for about fifty paces, anxiously and cautiously descending by a steep and dangerous way. Finding, however, that we came to a precipice which led into a spacious amphitheatre, if I may so call it, still deeper than any other part, we returned, and being provided with a ladder, flambeaux, and other things to expedite our descent, our whole company, man by

man, ventured into the same opening, and descending one after another, we at last saw ourselves all together in the most magnificent part of the cavern.

"Our candles being now all lighted up, and the whole place completely illuminated, never could the eye be presented with a more glittering, or a more magnificent scene. The roof all hung with solid icicles, transparent as glass, yet solid as marble. The eye could scarcely reach the lofty and noble ceiling; the sides were regularly formed with spars; and the whole presented the idea of a magnificent theatre, illuminated with an immense profusion of lights. The floor consisted of solid marble, and in several places, magnificent columns, thrones, altars, and other objects appeared, as if nature had designed to mock the curiosities of art. Our voices, upon speaking or singing, were redoubled to an astonishing loudness; and upon the firing of a gun, the noise and reverberations were almost deafening. In the midst of this grand amphitheatre rose a concretion of about fifteen feet high, that, in some measure, resembled an altar; from which, taking the hint, we caused mass to be celebrated there. The beautiful columns that shot up round the altar, appeared like candlesticks; and many other natural objects represented the customary ornaments of this sacrament.

"Below even this spacious grotto, there seemed another cavern; down which I ventured with my former mariner, and descended about fifty paces by means of a rope. I at last arrived at a small spot of level ground, where the bottom appeared different from that of the amphitheatre, being composed

of a soft clay, yielding to the pressure, and in which I thrust a stick to about six feet deep. In this, however, as above, numbers of the most beautiful crystals were formed: one of which, particularly, resembled a table. Upon our egress from this amazing cavern, we perceived a Greek inscription upon a rock at the mouth, but so obliterated by time that we could not read it. It seemed to import that one Antipater, in the time of Alexander, had come thither; but whether he penetrated into the depths of the cavern, he does not think fit to inform us."

Such is the account of this beautiful scene, as communicated in a letter to Kircher. We have another, and a more copious description of it by Tournefort, which is in every body's hands; but I have given the above, both because it was communicated by the first discoverer, and because it is a simple narrative of facts, without any reasoning upon them. According to Tournefort's account, indeed, we might conclude, from the rapid growth of the spars in this grotto, that it must every year be growing narrower, and that it must, in time, be choaked up with them entirely; but no such thing has happened hitherto, and the grotto, at this day, continues as spacious as we ever knew it.

This is not a place for an inquiry into the seeming vegetation of those stony substances with which this and almost every cavern are incrusted. It is enough to observe, in general, that they are formed by an accumulation of that little gritty matter which is carried thither by the waters, and which in time acquires the hardness of mar-

ble. What in this place more imports us to know is, how these amazing hollows in the earth came to be formed. And I think, in the three instances above mentioned, it is pretty evident, that their excavation has been owing to water. These finding subterraneous passages under the earth, and by long degrees hollowing the beds in which they flowed, the ground above them has slipt down closer to their surface, leaving the upper layers of the earth or stone still suspended. The ground that sinks upon the face of the waters forming the floor of the cavern; the ground, or rock that keeps suspended forming the roof: and, indeed, there are but few of these caverns found without water, either within them, or near enough to point out their formation.

CHAP. VIII.

Of Mines, Damps, and Mineral Vapours.

THE caverns, which we have been describing, generally carry us but a very little way below the surface of the earth. Two hundred feet at the utmost, is as much as the lowest of them is found to sink. The perpendicular fissures run much deeper; but few persons have been bold enough to venture down to their deepest recesses: and some few who have tried, have been able to bring back no tidings of the place, for unfortunately they left their lives below. The excavations of art have conducted us much farther into the bowels of the globe. Some mines in Hungary are known to be

a thousand yards perpendicular downwards; and I have been informed, by good authority, of a coal-mine in the north of England, a hundred yards deeper still.

It is beside our present purpose to enquire into the peculiar construction and contrivance of these, which more properly belongs to the history of fossils. It will be sufficient to observe in this place, that as we descend into the mines, the various layers of earth are seen, as we have already described them; and in some of these are always found the metals or minerals, for which the mine has been dug. Thus frequently gold is found dispersed and mixed with clay and gravel;* sometimes it is mingled with other metallic bodies, stones or bitumens; and sometimes † united with that most obstinate of all substances, platina, from which scarce any art can separate it. Silver is sometimes found quite pure, ‡ sometimes mixed with other substances and minerals. Copper is found in beds mixed with various substances, marbles, sulphurs, and pyrites. Tin, the ore of which is heavier than that of any other metal, is generally found mixed with every kind of matter: lead § is also equally common; and iron we well know can be extracted from all the substances upon earth.

The variety of substances which are thus found in the bowels of the earth, in their native state, have a very different appearance from what they are afterwards taught to assume by human

* Ulloa, vol. ii. p. 470. † Ulloa, ibid.
‡ Macquer's Chemistry, vol. i. p. 316.
§ Hill's Fossils, p. 628.

industry. The richest metals are very often less glittering and splendid than the most useless marcasites, and the basest ores are in general the most beautiful to the eye.

This variety of substances, which compose the internal parts of our globe, is productive of equal varieties both above and below its surface. The combination of the different minerals with each other, the heats which arise from their mixture, the vapours they diffuse, the fires which they generate, or the colds which they sometimes produce, are all either noxious or salutary to man; so that, in this great elaboratory of nature, a thousand benefits and calamities are forging, of which we are wholly unconscious; and it is happy for us that we are so.

* Upon our descent into mines of considerable depth, the cold seems to increase from the mouth as we descend; but after passing very low down, we begin, by degrees, to come into a warmer air, which sensibly grows hotter as we go deeper, till, at last, the labourers can scarcely bear any covering as they continue working.

This difference in the air was supposed by Boyle to proceed from magazines of fire that lay nearer the centre, and that diffused their heat to the adjacent regions. But we now know that it may be ascribed to more obvious causes. In some mines the composition of the earth all around is of such a nature, that, upon the admission of water or air, it frequently becomes hot, and often bursts out into eruptions. Besides

* Boyle, vol. iii. p. 232.

this, as the external air cannot readily reach the bottom, or be renewed there, an observable heat is perceived below, without the necessity of recurring to the central heat for an explanation.

Hence, therefore, there are two principal causes of the warmth at the bottom of mines: the heat of the substances of which the sides are composed; and the want of renovation in the air below. Any sulphureous substance mixed with iron, produces a very great heat, by the admission of water. If, for instance, a quantity of sulphur be mixed with a proportionable share of iron filings, and both kneaded together into a soft paste, with water, they will soon grow hot, and at last produce a flame. This experiment, produced by art, is very commonly effected within the bowels of the earth by nature. Sulphurs and irons are intimately blended together, and want only the mixture of water or air to excite their heat; and this, when once raised, is communicated to all bodies that lie within the sphere of their operation. Those beautiful minerals called marcasites and pyrites, are often of this composition; and wherever they are found, either by imbibing the moisture of the air, or having been by any means combined with water, they render the mine considerably hot *.

The want of fresh air, also, at these depths, is, as we have said, another reason for their being found much hotter. Indeed, without the assistance of art, the bottom of most mines would,

* Kircher Mund. Subt. vol. ii. p. 216.

from this cause, be insupportable. To remedy this inconvenience, the miners are often obliged to sink at some convenient distance from the mouth of the pit where they are at work, another pit, which joins the former below, and which, in Derbyshire, is called an air shaft. Through this the air circulates; and thus the workmen are enabled to breathe freely at the bottom of the place; which becomes, as Mr. Boyle affirms, very commodious for respiration; and also very temperate as to heat and cold.* Mr. Locke, however, who has left us an account of the Mendip mines, seems to present a different picture. "The descent into these is exceeding difficult and dangerous; for they are not sunk like wells, perpendicularly, but as the crannies of the rocks happen to run. The constant method is to swing down by a rope, placed under the arms, and clamber along, by applying both feet and hands to the sides of the narrow passage. The air is conveyed into them through a little passage that runs along the sides from the top, where they set up some turfs, on the lee-side of the hole, to catch and force it down. These turfs being removed to the windy side, or laid over the mouth of the hole, the miners below presently want breath, and faint; and if sweet-smelling flowers chance to be placed there, they immediately lose their fragrancy, and stink like carrion." An air so very putrefying can never be very commodious for respiration.

Indeed, if we examine the complexion of most

* Boyle, vol. iii. p. 238.

miners, we shall be very well able to form a judgment of the unwholesomeness of the place where they are confined. Their pale and sallow looks shew how much the air is damaged by passing through those deep and winding ways, that are rendered humid by damps, or warmed with noxious exhalations. But although every mine is unwholesome, all are not equally so. Coal-mines are generally less noxious than those of tin; tin than those of copper; but none are so dreadfully destructive as those of quicksilver. At the mines near the village of Idra, nothing can adequately describe the deplorable infirmities of such as fill the hospital there: emaciated and crippled, every limb contracted or convulsed, and some in a manner transpiring quicksilver at every pore. There was one man, says Dr. Pope,* who was not in the mines above half a year, and yet whose body was so impregnated with this mineral, that putting a piece of brass money in his mouth, or rubbing it between his fingers, it immediately became as white as if it had been washed over with quicksilver. In this manner all the workmen are killed, sooner or later; first becoming paralytic, and then dying consumptive: and all this they sustain for the trifling reward of sevenpence a day.

But these metallic mines are not so noxious from their own vapours, as from those of the substances with which the ores are usually united, such as arsenic, cinnabar, bitumen, or vitriol. From the fumes of these, variously combined,

* Phil. Trans. vol. ii. p. 578.

and kept enclosed, are produced those various damps that put on so many dreadful forms, and are usually so fatal. Sometimes those noxious vapours are perceived by the delightful fragrance of their smell,* somewhat resembling the pea-blossom in bloom, from whence one kind of damp has its name. The miners are not deceived, however, by its flattering appearances; but as they have thus timely notice of its coming, they avoid it while it continues, which is generally during the whole summer season. Another shews its approach by the burning of the candles, which seem to collect their flame into a globe of light, and thus gradually lessen, till they are quite extinguished. From this, also, the miners frequently escape; however, such as have the misfortune to be caught in it, either swoon away, and are suffocated, or slowly recover in excessive agonies. Here also is a third, called the fulminating damp, much more dangerous than either of the former, as it strikes down all before it, like a flash of gunpowder, without giving any warning of its approach. But there is another, more dangerous than all the rest, which is found in those places where the vapour has been long confined, and has been by some accident set free. The air rushing out from thence, always goes upon deadly errands; and scarce any escape to describe the symptoms of its operations.

Some colliers in Scotland, working near an old mine that had been long closed up, happened

* Phil. Trans. vol. ii. p. 375.

inadvertently to open a hole into it, from the pit where they were then employed. By great good fortune, they at that time perceived their error, and instantly fled for their lives. The next day, however, they were resolved to renew their work in the same pit, and eight of them ventured down, without any great apprehensions; but they had scarcely got to the bottom of the stairs that led to the pit, but coming within the vapour, they all instantly dropped down dead, as if they had been shot. Amongst these unfortunate poor men, there was one whose wife was informed that he was stifled in the mine; and as he happened to be next the entrance, she so far ventured down as to see where he lay. As she approached the place, the sight of her husband inspired her with a desire to rescue him, if possible, from that dreadful situation; though a little reflection might have shewn her it was then too late. But nothing could deter her; she ventured forward, and had scarcely touched him with her hand, when the damp prevailed, and the misguided, but faithful creature, fell dead by his side.

Thus, the vapours found beneath the surface of the earth are very various in their effects upon the constitution: and they are not less in their appearances. There are many kinds that seemingly are no way prejudicial to health, but in which the workmen breathe freely; and yet in these, if a lighted candle be introduced, they immediately take fire, and the whole cavern at once becomes one furnace of flame. In mines, therefore, subject to damps of this kind, they are obliged to have recourse to a very peculiar con-

trivance to supply sufficient light for their operations. This is by a great wheel, the circumference of which is beset with flints, which striking against steels placed for that purpose at the extremity, a stream of fire is produced, which affords light enough, and yet which does not set fire to the mineral vapour.

Of this kind are the vapours of the mines about Bristol: on the contrary, in other mines, a single spark struck out from the collision of flint and steel, would set the whole shaft in a flame. In such, therefore, every precaution is used to avoid a collision; the workmen making use only of wooden instruments in digging: and being cautious, before they enter the mine, to take out even the nails from their shoes. Whence this strange difference should arise, that the vapours of some mines catch fire with a spark, and others only with a flame, is a question that we must be content to leave in obscurity, till we know more of the nature both of mineral vapour and of fire. This only we may observe, that gunpowder will readily fire with a spark, but not with the flame of a candle: on the other hand, spirits of wine will flame with a candle, but not with a spark; but even here the cause of this difference, as yet, remains a secret.

As from this account of mines, it appears that the internal parts of the globe are filled with vapours of various kinds, it is not surprising, that they should at different times reach the surface, and there put on various appearances. In fact, much of the salubrity, and much of the unwholesomeness of climates and soils, is to be ascribed

to these vapours, which make their way from the bowels of the earth upwards, and refresh or taint the air with their exhalations. Salt-mines being naturally cold,* send forth a degree of coldness to the external air, to comfort and refresh it: on the contrary, metallic mines are known, not only to warm it with their exhalations, but often to destroy all kinds of vegetation by their volatile corrosive fumes. In some mines dense vapours are plainly perceived issuing from their mouths, and sensibly warm to the touch. In some places, neither snow nor ice will continue on the ground that covers a mine; and over others the fields are found destitute of verdure.† The inhabitants, also, are rendered dreadfully sensible of these subterraneous exhalations, being affected with such a variety of evils proceeding entirely from this cause, that books have been professedly written upon this class of disorders.

Nor are these vapours, which thus escape to the surface of the earth, entirely unconfined; for they are frequently, in a manner, circumscribed to a spot. The grotto Del Cane, near Naples, is an instance of this; the noxious effects of which have made that cavern so very famous. This grotto, which has so much employed the attention of travellers, lies within four miles of Naples, and is situated near a large lake of clear and wholesome water.‡ Nothing can exceed the beauty of the landscape which this lake affords; being surrounded with hills covered with forests

* Phil. Trans. vol. ii. p. 523. † Boyle, vol. iii. p. 238.
‡ Kircher Mund. Subt. vol. i. p. 191.

of the most beautiful verdure, and the whole bearing a kind of amphitheatrical appearance. However, this region, beautiful as it appears, is almost entirely uninhabited; the few peasants that necessity compels to reside there, looking quite consumptive and ghastly, from the poisonous exhalations that rise from the earth. The famous grotto lies on the side of a hill, near which place a peasant resides, who keeps a number of dogs, for the purpose of shewing the experiment to the curious. These poor animals always seem perfectly sensible of the approach of a stranger, and endeavour to get out of the way. However, their attempts being perceived, they are taken and brought to the grotto; the noxious effects of which they have so frequently experienced. Upon entering this place, which is a little cave, or hole rather, dug into the hill, about eight feet high and twelve feet long, the observer can see no visible marks of its pestilential vapour; only to about a foot from the bottom, the wall seems to be tinged with a colour resembling that which is given by stagnant waters. When the dog, this poor philosophical martyr, as some have called him, is held above this mark, he does not seem to feel the smallest inconvenience; but when his head is thrust down lower, he struggles to get free for a little; but in the space of four or five minutes he seems to lose all sensation, and is taken out seemingly without life. Being plunged in the neighbouring lake, he quickly recovers, and is permitted to run home seemingly without the smallest injury.

This vapour, which thus for a time suffocates,

is of a humid kind, as it extinguishes a torch, and sullies a looking-glass; but there are other vapours perfectly inflammable, and that only require the approach of a candle to set them blazing. Of this kind was the burning well at Brosely,* which is now stopped up; the vapour of which, when a candle was brought within about a foot of the surface of the water, caught flame like spirits of wine, and continued blazing for several hours after. Of this kind, also, are the perpetual fires in the kingdom of Persia. In that province, where the worshippers of fire hold their chief mysteries, the whole surface of the earth, for some extent, seems impregnated with inflammable vapours. A reed stuck into the ground continues to burn like a flambeau; a hole made beneath the surface of the earth, instantly becomes a furnace, answering all the purposes of a culinary fire. There they make lime by merely burying the stones in the earth, and watch with veneration the appearances of a flame that has not been extinguished for times immemorial.— How different are men in various climates! This deluded people worship these vapours as a deity, which in other parts of the world are considered as one of the greatest evils.

Volcano.

CHAP. IX.

Of Volcanoes and Earthquakes.

MINES and caverns, as we have said, reach but a very little way under the surface of the earth, and we have hitherto had no opportunities of exploring further. Without all doubt the wonders that are still unknown surpass those that have been represented, as there are depths of thousands of miles which are hidden from our enquiry. The only tidings we have from those unfathomable regions are by means of volcanoes, those burning mountains that seem to discharge their materials from the lowest abysses of the earth.* A volcano may be considered as a cannon of immense size, the mouth of which is often near two miles in circumference. From this dreadful aperture are discharged torrents of flame and sulphur, and rivers of melted metal. Whole clouds of smoke and ashes, with rocks of enormous size, are discharged to many miles distance; so that the force of the most powerful artillery is but as a breeze agitating a feather in comparison. In the deluge of fire and melted matter which runs down the sides of the mountain, whole cities are sometimes swallowed up and consumed. Those rivers of liquid fire are sometimes two hundred feet deep; and, when they harden, frequently form considerable hills. Nor is the

* Buffon, vol. i. p. 291.

danger of these confined to the eruption only: but the force of the internal fire struggling for vent, frequently produces earthquakes through the whole region where the volcano is situated. So dreadful have been these appearances, that men's terrors have added new horrors to the scene, and they have regarded as prodigies, what we know to be the result of natural causes. Some philosophers have considered them as vents communicating with the fires of the centre, and the ignorant as the mouths of hell itself. Astonishment produces fear, and fear superstition; the inhabitants of Iceland believe the bellowings of Hecla are nothing else but the cries of the damned, and that its eruptions are contrived to increase their tortures.

But if we regard this astonishing scene of terror with a more tranquil and inquisitive eye, we shall find that these conflagrations are produced by very obvious and natural causes. We have already been apprized of the various mineral substances in the bosom of the earth, and their aptness to burst out into flames. Marcasites and pyrites, in particular, by being humified with water, or air, contract this heat, and often endeavour to expand with irresistible explosion. These, therefore, being lodged in the depths of the earth, or in the bosom of mountains, and being either washed by the accidental influx of waters below, or fanned by air, insinuating itself through perpendicular fissures from above, take fire at first by only heaving in earthquakes, but, at length, by bursting through every obstacle, and making their dreadful discharge in a volcano.

These volcanoes are found in all parts of the earth: in Europe there are three that are very remarkable; Ætna in Sicily, Vesuvius in Italy, and Hecla in Iceland. Ætna has been a volcano for ages immemorial. Its eruptions are very violent, and its discharge has been known to cover the earth sixty-eight feet deep. In the year 1537, an eruption of this mountain produced an earthquake through the whole island, for twelve days, overturned many houses, and at last formed a new aperture, which overwhelmed all within five leagues round. The cinders thrown up were driven even into Italy, and its burnings were seen at Malta at the distance of sixty leagues. There is nothing more awful, says Kircher, than the eruptions of this mountain, nor nothing more dangerous than attempting to examine its appearances, even long after the eruption has ceased. As we attempt to clamber up its steepy sides, every step we take upward, the feet sink back half way. Upon arriving near the summit, ashes and snow, with an ill-assorted conjunction, present nothing but objects of desolation. Nor is this the worst, for, as all places are covered over, many caverns are entirely hidden from the sight, into which, if the enquirer happens to fall, he sinks to the bottom, and meets inevitable destruction. Upon coming to the edge of the great crater, nothing can sufficiently represent the tremendous magnificence of the scene. A gulph two miles over, and so deep that no bottom can be seen; on the sides pyramidical rocks starting out between apertures that emit smoke and flame; all this accompanied with a sound that never ceases, louder than thunder, strikes the bold with horror,

and the religious with veneration for him that has power to control its burnings.

In the descriptions of Vesuvius, or Hecla, we shall find scarcely any thing but a repetition of the same terrible objects, but rather lessened, as these mountains are not so large as the former. The crater of Vesuvius is but a mile across, according to the same author; whereas that of Ætna is two. On this particular, however, we must place no dependance, as these caverns every day alter; being lessened by the mountains sinking in at one eruption, and enlarged by the fury of another. It is not one of the least remarkable particulars respecting Vesuvius, that Pliny the naturalist was suffocated in one of its eruptions; for his curiosity impelling him too near, he found himself involved in smoke and cinders when it was too late to retire; and his companions hardly escaped to give an account of the misfortune. It was in that dreadful eruption that the city of Herculaneum was overwhelmed, the ruins of which have been lately discovered at sixty feet distance below the surface, and, what is still more remarkable, forty feet below the bed of the sea. One of the most remarkable eruptions of this mountain was in the year 1707; which is finely described by Valetta, a part of whose description I shall beg leave to translate.

"Towards the latter end of summer, in the year 1707, the mount Vesuvius, that had for a long time been silent, now began to give some signs of commotion. Little more than internal murmurs at first were heard, that seemed to contend within the lowest depths of the mountain; no flame, nor even

any smoke, was as yet seen. Soon after some smoke appeared by day, and a flame by night, which seemed to brighten all the campania. At intervals also it shot off substances with a sound very like that of artillery, but which, even at so great a distance as we were at, infinitely exceeded them in greatness. Soon after it began to throw up ashes, which becoming the sport of the winds, fell at great distances, and some many miles. To this succeeded showers of stones, which killed many of the inhabitants of the valley, but made a dreadful ravage among the cattle. Soon after a torrent of burning matter began to roll down the sides of the mountain, at first with a slow and gentle motion, but soon with increased celerity. The matter thus poured out, when cold, seemed, upon inspection, to be of vitrified earth, the whole united into a mass of more than stony hardness: But what was particularly observable was, that, upon the whole surface of these melted materials, a light spongy stone seemed to float, while the lower body was of the hardest substance, of which our roads are usually made. Hitherto there were no appearances but what had been often remarked before: but on the third or fourth day, seeming flashes of lightning were shot forth from the mouth of the mountain, with a noise far exceeding the loudest thunder. These flashes, in colour and brightness, resembled what we usually see in tempests, but they assumed a more twisted and serpentine form. After this followed such clouds of smoke and ashes, that the whole city of Naples, in the midst of the day, was involved in nocturnal darkness, and the nearest friends were unable to

distinguish each other in this frightful gloom. If any person attempted to stir out without torch-light he was obliged to return, and every part of the city was filled with supplications and terror; at length, after a continuance of some hours, about one o'clock at midnight, the wind blowing from the north, the stars began to be seen; the heavens, though it was night, began to grow brighter; and the eruptions, after a continuance of fifteen days, to lessen. The torrent of melted matter was seen to extend from the mountain down to the shore; the people began to return to their former dwellings, and the whole face of nature to resume its former appearance."

The famous bishop Berkley gives an account of one of these eruptions in a manner something differing from the former. * "In the year 1717, and the middle of April, with much difficulty I reached the top of mount Vesuvius, in which I saw a vast aperture full of smoke, which hindered me from seeing its depth and figure. I heard within that horrid gulph certain extraordinary sounds, which seemed to proceed from the bowels of the mountain, a sort of murmuring, sighing, dashing sound, and between whiles a noise like that of thunder or cannon, with a clattering like that of tiles falling from the tops of houses into the streets. Sometimes, as the wind changed, the smoke grew thinner, discovering a very ruddy flame, and the circumference of the crater streaked with red and several shades of yellow. After an hour's stay, the smoke being moved by the wind, gave us short

* Phil. Trans. vol. ii. p. 209.

and partial prospects of the great hollow: in the flat bottom of which I could discern two furnaces almost contiguous; that on the left seeming about three yards over, glowing with ruddy flame, and throwing up red-hot stones, with a hideous noise, which, as they fell back, caused the clattering already taken notice of. May 8, in the morning, I ascended the top of Vesuvius a second time, and found a different face of things. The smoke ascending upright, gave a full prospect of the crater, which, as I could judge, was about a mile in circumference, and a hundred yards deep. A conical mount had been formed since my last visit, in the middle of the bottom, which I could see was made by the stones, thrown up and fallen back again into the crater. In this new hill remained the two furnaces already mentioned. The one was seen to throw up every three or four minutes, with a dreadful sound, a vast number of red-hot stones, at least three hundred feet higher than my head, as I stood upon the brink; but as there was no wind, they fell perpendicularly back from whence they had been discharged. The other was filled with red-hot liquid matter, like that in the furnace of a glass-house; raging and working like the waves of the sea, with a short abrupt noise. This matter would sometimes boil over, and run down the side of the conical hill, appearing at first red-hot, but changing colour as it hardened and cooled. Had the wind driven in our faces, we had been in no small danger of stifling by the sulphureous smoke, or being killed by the masses of melted minerals, that were shot from the bot-

tom. But as the wind was favourable, I had an opportunity of surveying this amazing scene for above an hour and a half together. On the 5th of June, after a horrid noise, the mountain was seen at Naples to work over; and, about three days after, its thunders were renewed so, that not only the windows in the city, but all the houses shook. From that time it continued to overflow, and sometimes at night were seen columns of fire shooting upward from its summit. On the tenth, when all was thought to be over, the mountain again renewed its terrors, roaring and raging most violently. One cannot form a juster idea of the noise, in the most violent fits of it, than by imagining a mixed sound, made up of the raging of a tempest, the murmur of a troubled sea, and the roaring of thunder and artillery, confused all together. Though we heard this at a distance of twelve miles, yet it was very terrible. I therefore resolved to approach nearer to the mountain; and, accordingly, three or four of us got into a boat, and were set ashore at a little town, situated at the foot of the mountain. From thence we rode about four or five miles, before we came to the torrent of fire that was descending from the side of the volcano; and here the roaring grew exceeding loud and terrible as we approached. I observed a mixture of colours in the cloud, above the crater, green, yellow, red, blue. There was likewise a ruddy dismal light in the air, over that tract where the burning river flowed. These circumstances, set off and augmented by the horror of the night, made a scene the most uncommon and astonishing I ever saw;

which still increased as we approached the burning river. Imagine a vast torrent of liquid fire, rolling from the top down the side of the mountain, and with irresistible fury bearing down and consuming vines, olives, and houses; and divided into different channels, according to the inequalities of the mountain. The largest stream seemed half a mile broad at least, and five miles long. I walked so far before my companions up the mountain, along the side of the river of fire, that I was obliged to retire in great haste, the sulphureous steam having surprised me, and almost taken away my breath. During our return, which was about three o'clock in the morning, the roaring of the mountain was heard all the way, while we observed it throwing up huge spouts of fire and burning stones, which falling resembled the stars in a rocket. Sometimes I observed two or three distinct columns of flame, and sometimes one only, that was large enough to fill the whole crater. These burning columns, and fiery stones, seemed to be shot a thousand feet perpendicular above the summit of the volcano: and in this manner the mountain continued raging for six or eight days after. On the eighteenth of the same month the whole appearance ended, and the mountain remained perfectly quiet, without any visible smoke or flame."

The matter which is found to roll down from the mouth of all volcanoes in general, resembles the dross that is thrown from a smith's forge. But it is different, perhaps, in various parts of the globe; for, as we have already said, there is not a quarter of the world that has not its

volcanoes. In Asia, particularly in the islands of the Indian ocean, there are many. One of the most famous is that of Albouras, near Mount Taurus, the summit of which is continually on fire, and covers the whole adjacent country with ashes. In the island of Ternate there is a volcano, which, some travellers assert, burns most furiously in the times of the equinoxes, because of the winds which then contribute to increase the flames. In the Molucca islands, there are many burning mountains; they are also seen in Japan, and the islands adjacent; and in Java and Sumatra, as well as in other of the Philippine islands. In Africa, there is a cavern, near Fez, which continually sends forth either smoke or flames. In the Cape de Verde islands, one of them, called the Island del Fuego, continually burns; and the Portuguese, who frequently attempted a settlement there, have as often been obliged to desist. The Peak of Teneriffe is, as every body knows, a volcano that seldom desists from eruptions. But of all parts of the earth, America is the place where those dreadful irregularities of nature are the most conspicuous. Vesuvius, and Ætna itself, are but mere fire-works, in comparison to the burning mountains of the Andes; which, as they are the highest mountains of the world, so also are they the most formidable for their eruptions. The mountain of Arequipa, in Peru, is one of the most celebrated; Carassa, and Malahallo, are very considerable; but that of Cotopaxi, in the province of Quito, exceeds any thing we have hitherto read or heard of. The mountain of Cotopaxi, as described by

Ulloa,* is more than three miles perpendicular from the sea; and it became a volcano at the time of the Spaniards' first arrival in that country. A new eruption of it happened in the year 1743, having been some days preceded by a continual roaring in its bowels. The sound of one of these mountains is not like that of the volcanoes in Europe, confined to a province, but is heard at a hundred and fifty miles distance.† "An aperture was made in the summit of this immense mountain; and three more about equal heights, near the middle of its declivity, which was at that time buried under prodigious masses of snow. The ignited substances ejected on that occasion, mixed with a prodigious quantity of ice and snow, melting amidst the flames, were carried down with such astonishing rapidity, that in an instant the valley from Callo to Latucunga was overflowed; and besides its ravages in bearing down the houses of the Indians, and other poor inhabitants, great numbers of people lost their lives. The river of Latucunga was the channel of this terrible flood; till being too small for receiving such a prodigious current, it overflowed the adjacent country, like a vast lake, near the town, and carried away all the buildings within its reach. The inhabitants retired to a spot of higher ground behind the town, of which those parts which stood within the limits of the current were totally destroyed. The dread of still greater devastations did not subside for three days; during which the volcano ejected cinders, while torrents of melted ice and

* Ulloa, vol. i. p. 442. † Ibid.

snow poured down its sides. The eruption lasted several days, and was accompanied with terrible roarings of the wind, rushing through the volcano still louder than the former rumblings in its bowels. At last all was quiet, neither fire nor smoke to be seen, nor noise to be heard; till, in the ensuing year, the flames again appeared with recruited violence, forcing their passage through several other parts of the mountain, so that in clear nights the flames being reflected by the transparent ice, formed an awfully magnificent illumination."

Such is the appearance and the effect of those fires which proceed from the more inward recesses of the earth; for that they generally come from deeper regions than man has hitherto explored, I cannot avoid thinking, contrary to the opinion of M. Buffon, who supposes them rooted but a very little way below the bed of the mountain. We can never suppose, says this great naturalist, that these substances are ejected from any great distance below, if we only consider the great force already required to fling them up to such vast heights above the mouth of the mountain; if we consider the substances thrown up, which we shall find, upon inspection, to be the same with those of the mountain below; if we take into our consideration, that air is always necessary to keep up the flame; but, most of all, if we attend to one circumstance, which is, that if these substances were exploded from a vast depth below, the same force required to shoot them up so high, would act against the sides of the volcano, and tear the whole mountain in pieces. To all this specious

reasoning, particular answers might be easily given; as, that the length of the funnel increases the force of the explosion; that the sides of the funnel are actually often burst with the great violence of the flame; that air may be supposed at depths at least as far as the perpendicular fissures descend. But the best answer is a well-known fact; namely, that the quantity of matter discharged from Ætna alone, is supposed, upon a moderate computation, to exceed twenty times the original bulk of the mountain.* The greatest part of Sicily seems covered with its eruptions. The inhabitants of Catanea have found, at the distance of several miles, streets and houses, sixty feet deep, overwhelmed by the lava or matter it has discharged. But what is still more remarkable, the walls of these very houses have been built of materials evidently thrown up by the mountain. The inference from all this is very obvious; that the matter thus exploded cannot belong to the mountain itself, otherwise, it would have been quickly consumed; it cannot be derived from moderate depths, since its amazing quantity evinces that all the places near the bottom must have long since been exhausted; nor can it have an extensive, and, if I may so call it, a superficial spread, for then the country round would be quickly undermined; it must, therefore, be supplied from the deeper regions of the earth; those undiscovered tracts where the Deity performs his wonders in solitude, satisfied with self-approbation!

* Kircher, Mund. Subt. vol. i. p. 202.

CHAP. X.

Of Earthquakes.

HAVING given the theory of volcanoes, we have in some measure given also that of earthquakes. They both seem to proceed from the same cause, only with this difference, that the fury of the volcano is spent in the eruption, that of an earthquake spreads wider, and acts more fatally by being confined. The volcano only affrights a province, earthquakes have laid whole kingdoms in ruin.

Philosophers * have taken some pains to distinguish between the various kinds of earthquakes, such as the tremulous, the pulsative, the perpendicular, and the inclined; but these are rather the distinctions of art than of nature, mere accidental differences, arising from the situation of the country or of the cause. If, for instance, the confined fire acts directly under a province or a town, it will heave the earth perpendicularly upward, and produce a *perpendicular* earthquake. If it acts at a distance, it will raise that tract obliquely, and thus the inhabitants will perceive an *inclined* one.

Nor does it seem to me that there is much greater reason for M. Buffon's distinction of earthquakes, one kind of which he supposes † to be produced by fire, in the manner of volcanoes, and confined but to a very narrow circumference. The

* Aristotle, Agricola, Buffon. † Buffon, vol. ii. p. 328.

other kind he ascribes to the struggles of confined air, expanded by heat in the bowels of the earth, and endeavouring to get free. For how do these two causes differ? Fire is an agent of no power whatsoever without air. It is the air, which being at first compressed, and then dilated in a cannon, that drives the ball with such force. It is the air struggling for vent in a volcano, that throws up its contents to such vast heights. In short, it is the air confined in the bowels of the earth, and acquiring elasticity by heat, that produces all those appearances generally ascribed to the operation of fire. When, therefore, we are told that there are two causes of earthquakes, we only learn, that a greater or smaller quantity of heat produces those terrible effects; for air is the only active operator in either.

Some philosophers, however, have been willing to give the air as great a share in producing these terrible efforts as they could; and, magnifying its powers, have called in but a very moderate degree of heat to put it in action. Although experience tells us that the earth is full of inflammable materials, and that fires are produced wherever we descend; although it tells us that those countries, where there are volcanoes, are most subject to earthquakes, yet they step out of the way, and so find a new solution. These only allow but just heat enough to produce the most dreadful phænomena, and backing their assertions with long calculations, give theory an air of demonstration. M. Amontons * has been particularly

* Mémoires de l'Académie des Sciences, an. 1703.

sparing of the internal heat in this respect; and has shown, perhaps accurately enough, that a very moderate degree of heat may suffice to give the air amazing powers of expansion.

It is astonishing, however, to trace the progress of a philosophical fancy let loose in imaginary speculations. They run thus: "A very moderate degree of heat may bring the air into a condition capable of producing earthquakes; for the air at the depth of forty-three thousand five hundred and twenty-eight fathom below the surface of the earth, becomes almost as heavy as quicksilver. This, however, is but a very slight depth in comparison of the distance to the centre, and is scarcely a seventieth part of the way. The air, therefore, at the centre, must be infinitely heavier than mercury, or any body that we know of. This granted, we shall take something more, and say, that it is very probable there is nothing but air at the centre. Now let us suppose this air heated, by some means, even to the degree of boiling water, as we have proved that the density of the air is here very great, its elasticity must be in proportion; a heat, therefore, which at the surface of the earth would have produced but a slight expansive force, must at the centre produce one very extraordinary, and, in short, be perfectly irresistible. Hence this force may, with great ease, produce earthquakes; and, if increased, it may convulse the globe; it may, by only adding figures enough to the calculation, destroy the solar system, and even the fixed stars themselves." These reveries generally produce nothing; for, as I have ever

observed, increased calculations, while they seem to tire the memory, give the reasoning faculty perfect repose.

However, as earthquakes are the most formidable ministers of nature, it is not to be wondered that a multitude of writers have been curiously employed in the consideration of their cause. Woodward has ascribed them to a stoppage of the waters below the earth's surface, by some accident. These being thus accumulated, and yet acted upon by fires, which he supposes still deeper, both contribute to heave up the earth upon their bosom. This, he thinks, accounts for the lakes of water produced in an earthquake, as well as for the fires that sometimes burst from the earth's surface upon those dreadful occasions. There are others who have supposed that the earth may be itself the cause of its own convulsions. When, say they, the root or basis of some large tract is worn away by a fluid underneath, the earth sinking therein, its weight occasions a tremor of the adjacent parts, sometimes producing a noise, and sometimes an inundation of water. Not to tire the reader with a history of opinions instead of facts, some have ascribed them to electricity, and some to the same causes that produce thunder.

It would be tedious, therefore, to give all the various opinions that have employed the speculative upon this subject. The activity of the internal heat seems alone sufficient to account for every appearance that attends these tremendous irregularities of nature. To conceive this distinctly, let us suppose, at some vast distance under the earth, large quantities of inflammable

matter, pyrites, bitumens, and marcasites disposed, and only waiting for the aspersion of water, or the humidity of the air, to put their fires in motion; at last, this dreadful mixture arrives; waters find their way into those depths, through the perpendicular fissures: or air insinuates itself through the same minute apertures; immediately new appearances ensue: those substances, which for ages before lay dormant, now conceive new apparent qualities; they grow hot, produce new air, and only want room for expansion. However, the narrow apertures by which the air or water had at first admission, are now closed up; yet as new air is continually generated, and as the heat every moment gives this air new elasticity, it at length bursts, and dilates all round; and, in its struggles to get free, throws all above it into similar convulsions. Thus an earthquake is produced, more or less extensive, according to the depth or the greatness of the cause.

But before we proceed with the causes, let us take a short view of the appearances which have attended the most remarkable earthquakes. By these we shall see how far the theorist corresponds with the historian. The greatest we find in antiquity, is that mentioned by Pliny,* in which twelve cities in Asia Minor were swallowed up in one night. He tells us also of another, near the lake Thrasymene, which was not perceived by the armies of the Carthaginians and Romans, that were then engaged near that lake, although it shook the greatest part of Italy. In another

* Plin. lib. ii. cap. 86.

place* he gives the following account of an earthquake of an extraordinary kind. "When Lucius Marcus, and Sextus Julius, were consuls, there appeared a very strange prodigy of the earth (as I have read in the books of Ætruscan discipline) which happened in the province of Mutina. Two mountains shocked against each other, approaching and retiring with the most dreadful noise. They, at the same time, and in the midst of the day, appeared to cast forth fire and smoke, while a vast number of Roman knights and travellers from the Æmilian way, stood and continued amazed spectators. Several towns were destroyed by this shock; and all the animals that were near them were killed." In the times of Trajan, the city of Antioch, and a great part of the adjacent country, was buried by an earthquake. About three hundred years after, in the times of Justinian, it was once more destroyed, together with forty thousand inhabitants; and, after an interval of sixty years, the same ill-fated city was a third time overturned, with the loss of not less than sixty thousand souls. In the year 1182, most of the cities of Syria, and the kingdom of Jerusalem, were destroyed by the same accident. In the year 1594, the Italian historians describe an earthquake at Puteoli, which caused the sea to retire two hundred yards from its former bed.

But one of those most particularly described in history, is that of the year 1693; the damages of which were chiefly felt in Sicily, but its mo-

* Plin. lib. iii. cap. 85.

tion perceived in Germany, France, and England. It extended to a circumference of two thousand six hundred leagues; chiefly affecting the sea-coast and great rivers; more perceivable, also, upon the mountains than in the vallies. Its motions were so rapid, that those who lay at their length, were tossed from side to side, as upon a rolling billow.* The walls were dashed from their foundations; and no less than fifty-four cities, with an incredible number of villages, were either destroyed or greatly damaged. The city of Catanea, in particular, was utterly overthrown. A traveller, who was on his way thither, at the distance of some miles, perceived a black cloud, like night, hanging over the place. The sea, all of a sudden, began to roar; Mount Ætna to send forth great spires of flame; and soon after a shock ensued, with a noise as if all the artillery in the world had been at once discharged. Our traveller being obliged to alight instantly, felt himself raised a foot from the ground, and turning his eyes to the city, he with amazement saw nothing but a thick cloud of dust in the air. The birds flew about astonished; the sun was darkened; the beasts ran howling from the hills; and, although the shock did not continue above three minutes, yet near nineteen thousand of the inhabitants of Sicily perished in the ruins. Catanea, to which city the describer was travelling, seemed the principal scene of ruin; its place only was to be found; and not a footstep of its former magnificence was to be seen remaining.

* Phil. Trans.

The earthquake which happened in Jamaica, in 1692, was very terrible, and its description sufficiently minute. "In two minutes time it destroyed the town of Port Royal, and sunk the houses in a gulph forty fathoms deep. It was attended with a hollow rumbling noise, like that of thunder; and, in less than a minute, three parts of the houses, and their inhabitants, were all sunk quite under water. While they were thus swallowed up on one side of the street, on the other the houses were thrown into heaps; the sand of the street rising like the waves of the sea, lifting up those that stood upon it, and immediately overwhelming them in pits. All the wells discharged their waters with the most vehement agitation. The sea felt an equal share of turbulence, and, bursting over its mounds, deluged all that came in its way. The fissures of the earth were, in some places, so great, that one of the streets appeared twice as broad as formerly. In many places, however, it opened and closed again, and continued this agitation for some time. Of these openings, two or three hundred might be seen at a time; in some whereof the people were swallowed up; in others, the earth closing, caught them by the middle, and thus crushed them instantly to death. Other openings, still more dreadful than the rest, swallowed up whole streets; and others, more formidable, spouted up whole cataracts of water, drowning such as the earthquake had spared. The whole was attended with the most noisome stench; while the thundering of the distant falling mountains, the whole sky overcast with a dusky gloom, and the crash

of falling habitations, gave unspeakable horror to the scene. After this dreadful calamity was over, the whole island seemed converted into a scene of desolation; scarcely a planter's house was left standing; almost all were swallowed up; houses, people, trees, shared one universal ruin; and, in their places, appeared great pools of water, which, when dried up by the sun, left only a plain of barren sand, without any vestige of former inhabitants. Most of the rivers, during the earthquake, were stopt up by the falling in of the mountains; and it was not till after some time that they made themselves new channels. The mountains seemed particularly attacked by the force of the shock; and it was supposed that the principal seat of the concussion was among them. Those who were saved, got on board ships in the harbour; where many remained above two months, the shocks continuing, during that interval, with more or less violence every day."

As this description seems to exhibit all the appearances that usually make up the catalogue of terrors belonging to an earthquake, I will suppress the detail of that which happened at Lisbon, in our own times, and which is too recent to require a description. In fact, there are few particulars in the accounts of those who were present at that scene of desolation, that we have not more minutely and accurately transmitted to us by former writers, whose narratives I have for that reason preferred. I will therefore close this description of human calamities, with the account of the dreadful earthquake at Calabria, in

1638. It is related by the celebrated Father Kircher, as it happened while he was on his journey to visit Mount Ætna, and the rest of the wonders that lie towards the south of Italy. I need scarcely inform the reader that Kircher is considered, by scholars, as one of the greatest prodigies of learning.

"Having hired a boat, in company with four more, two friars of the order of St. Francis, and two seculars, we launched, on the twenty-fourth of March, from the harbour of Messina, in Sicily, and arrived, the same day, at the promontory of Pelorus. Our destination was for the city of Euphæmia, in Calabria, where we had some business to transact, and where we designed to tarry for some time. However, Providence seemed willing to cross our design; for we were obliged to continue for three days at Pelorus, upon account of the weather, and though we often put out to sea, yet we were as often driven back. At length, however, wearied with the delay, we resolved to prosecute our voyage; and, although the sea seemed more than usually agitated, yet we ventured forward. The gulph of Charybdis, which we approached, seemed whirled round in such a manner, as to form a vast hollow, verging to a point in the centre. Proceeding onward, and turning my eyes to Ætna, I saw it cast forth large volumes of smoke, of mountainous sizes, which entirely covered the whole island, and blotted out the very shores from my view. This, together with the dreadful noise, and the sulphureous stench, which was strongly perceived, filled me with apprehensions that some more dreadful cala-

mity was impending. The sea itself seemed to wear a very unusual appearance; those who have seen a lake in a violent shower of rain covered all over with bubbles, will conceive some idea of its agitations. My surprise was still increased by the calmness and serenity of the weather; not a breeze, not a cloud which might be supposed to put all Nature thus into motion. I therefore warned my companions that an earthquake was approaching; and, after some time, making for the shore with all possible diligence, we landed at Tropæ, happy and thankful for having escaped the threatening dangers of the sea.

"But our triumphs at land were of short duration; for we had scarcely arrived at the Jesuits College in that city, when our ears were stunned with a horrid sound, resembling that of an infinite number of chariots driven fiercely forward, the wheels rattling, and the thongs cracking. Soon after this, a most dreadful earthquake ensued; so that the whole tract upon which we stood seemed to vibrate, as if we were in the scale of a balance that continued wavering. This motion, however, soon grew more violent; and being no longer able to keep my legs, I was thrown prostrate upon the ground. In the mean time, the universal ruin round me redoubled my amazement. The crash of falling houses, the tottering of towers, and the groans of the dying, all contributed to raise my terror and despair. On every side of me I saw nothing but a scene of ruin; and danger threatening wherever I should fly. I commended myself to God as my last great refuge. At that hour, O how vain was every sublunary happiness! Wealth,

honour, empire, wisdom, all mere useless sounds, and as empty as the bubbles in the deep. Just standing on the threshold of eternity, nothing but God was my pleasure; and the nearer I approached, I only loved him the more. After some time, however, finding that I remained unhurt, amidst the general concussion, I resolved to venture for safety, and running as fast as I could, reached the shore, but almost terrified out of my reason. I did not search long here till I found the boat in which I had landed, and my companions also, whose terrors were even greater than mine. Our meeting was not of that kind where every one is desirous of telling his own happy escape; it was all silence, and a gloomy dread of impending terrors.

"Leaving this seat of desolation, we prosecuted our voyage along the coast; and the next day came to Rochetta, where we landed, although the earth still continued in violent agitations. But we were scarcely arrived at our inn, when we were once more obliged to return to the boat; and, in about half an hour, we saw the greatest part of the town, and the inn at which we had set up, dashed to the ground, and burying all its inhabitants beneath its ruins.

"In this manner, proceeding onward in our little vessel, finding no safety at land, and yet, from the smallness of our boat, having but a very dangerous continuance at sea, we at length landed at Lopizium, a castle midway between Tropæ and Euphæmia, the city to which, as I said before, we were bound. Here, wherever I turned my eyes, nothing but scenes of ruin and horror appeared; towns and castles levelled to the ground; Strom-

boli, though at sixty miles distance, belching forth flames in an unusual manner, and with a noise which I could distinctly hear. But my attention was quickly turned from more remote to contiguous danger. The rumbling sound of an approaching earthquake, which we by this time were grown acquainted with, alarmed us for the consequences; it every moment seemed to grow louder, and to approach more near. The place on which we stood now began to shake most dreadfully; so that being unable to stand, my companions and I caught hold of whatever shrub grew next us, and supported ourselves in that manner.

"After some time, this violent paroxysm ceasing, we again stood up, in order to prosecute our voyage to Euphæmia, that lay within sight In the mean time, while we were preparing for this purpose, I turned my eyes towards the city, but could see only a frightful dark cloud, that seemed to rest upon the place. This the more surprised us, as the weather was so very serene. We waited, therefore, till the cloud was passed away: then turning to look for the city, it was totally sunk. Wonderful to tell! nothing but a dismal and putrid lake was to be seen where it stood. We looked about to find some one that could tell us of its sad catastrophe, but could see none. All was become a melancholy solitude; a scene of hideous desolation. Thus proceeding pensively along, in quest of some human being, that could give us some little information, we, at length, saw a boy sitting by the shore, and appearing stupified with terror. Of him, therefore, we inquired concerning the fate of the city; but he could not be prevailed

on to give us an answer. We entreated him with every expression of tenderness and pity to tell us; but his senses were quite wrapt up in the contemplation of the danger he had escaped. We offered him some victuals, but he seemed to loath the sight.

"We still persisted in our offices of kindness; but he only pointed to the place of the city, like one out of his senses; and then running up into the woods, was never heard of after. Such was the fate of the city of Euphæmia: and as we continued our melancholy course along the shore, the whole coast, for the space of two hundred miles, presented nothing but the remains of cities; and men scattered, without an habitation, over the fields. Proceeding thus along, we at length ended our distressful voyage by arriving at Naples, after having escaped a thousand dangers both at sea and land."

The reader, I hope, will excuse me for this long translation from a favourite writer, and that the sooner, as it contains some particulars relative to earthquakes not to be found elsewhere. From the whole of these accounts we may gather, that the most concomitant circumstances are these:

A rumbling sound before the earthquake. This proceeds from the air, or fire, or both, forcing their way through the chasms of the earth, and endeavouring to get free, which is also heard in volcanoes.

A violent agitation, or heaving of the sea, sometimes before and sometimes after that at land. This agitation is only a similar effect produced on the waters with that at land, and may be called, for

the sake of perspicuity, a sea-quake; and this also is produced by volcanoes.

A spouting up of waters to great heights. It is not easy to describe the manner in which this is performed; but volcanoes also perform the same, Vesuvius being known frequently to eject a vast body of water.

A rocking of the earth to and fro, and sometimes a perpendicular bouncing, if it may be so called, of the same. This difference chiefly arises from the situation of the place with respect to the subterranean fire. Directly under, it lifts; at a farther distance, it rocks.

Some earthquakes seem to travel onward, and are felt in different countries at different hours the same day. This arises from the great shock being given to the earth at one place, and that being communicated onward by an undulatory motion, successively affects different regions in its progress; as the blow given by a stone falling in a lake is not perceived at the shores till some time after the first concussion.

The shock is sometimes instantaneous, like the explosion of gunpowder; and sometimes tremulous, and continuing for several minutes. The nearer the place where the shock is first given, the more instantaneous and simple it appears. At a greater distance, the earth redoubles the first blow, with a sort of vibratory continuation.

As waters have generally so great a share in producing earthquakes, it is not to be wondered that they should generally follow those breaches made by the force of fire, and appear in the great chasms which the earthquake has opened.

These are some of the most remarkable phænomena of earthquakes, presenting a frightful assemblage of the most terrible effects of air, earth, fire, and water.

The valley of Solfatara, near Naples, seems to exhibit, in a minuter degree, whatever is seen of this horrible kind, on the great theatre of Nature. This plain, which is about twelve hundred feet long, and a thousand broad, is embosomed in mountains, and has in the middle of it a lake of noisome blackish water, covered with a bitumen, that floats upon its surface. In every part of this plain, caverns appear smoking with sulphur, and often emitting flames. The earth, wherever we walk over it, trembles beneath the feet. Noises of flames, and the hissing of waters are heard at the bottom. The water sometimes spouts up eight or ten feet high. The most noisome fumes, fetid water, and sulphureous vapours, offend the smell. A stone thrown into any of the caverns, is ejected again with considerable violence. These appearances generally prevail when the sea is any way disturbed; and the whole seems to exhibit the appearance of an earthquake in miniature. However, in this smaller scene of wonders, as well as in the greater, there are many appearances for which perhaps we shall never account; and many questions may be asked, which no conjectures can thoroughly resolve. It was the fault of the philosophers of the last age, to be more inquisitive after the causes of things, than after the things themselves. They seemed to think that a confession of ignorance cancelled their claims to wisdom: they, therefore, had a solution for every demand.

But the present age has grown, if not more inquisitive, at least more modest; and none are now ashamed of that ignorance which labour can neither remedy nor remove.

CHAP. XI.

Of the appearance of New Islands, and Tracts; and of the disappearing of others.

HITHERTO we have taken a survey only of the evils which are produced by subterranean fires, but we have mentioned nothing of the benefits they may possibly produce. They may be of use in warming and cherishing the ground, in promoting vegetation, and giving a more exquisite flavour to the productions of the earth. The imagination of a person who has never been out of our own mild region, can scarcely reach to that luxuriant beauty with which all nature appears clothed in those very countries that we have but just now described as desolated by earthquakes, and undermined by subterranean fires. It must be granted, therefore, that though in those regions they have a greater share in the dangers, they have also a larger proportion in the benefits of Nature.

But there is another advantage arising from subterranean fires, which, though hitherto disregarded by man, yet may one day become serviceable to him; I mean, that while they are found to swallow up cities and plains in one place, they are also known to produce promontories and islands in another. We have many instances of islands

being thus formed in the midst of the sea, which though for a long time barren, have afterwards become fruitful seats of happiness and industry.

New islands are formed in two ways; either suddenly, by the action of subterraneous fires; or more slowly, by the deposition of mud, carried down by rivers, and stopped by some accident.* With respect particularly to the first, ancient historians, and modern travellers, give us such accounts as we can have no room to doubt of. Seneca assures us, that in his time the island of Therasia appeared unexpectedly to some mariners, as they were employed in another pursuit. Pliny assures us, that thirteen islands in the Mediterranean appeared at once emerging from the water; an occurrence which he ascribes rather to the retiring of the sea in those parts, than to any subterraneous elevation. However, he mentions the island of Hiera, near that of Therasia, as formed by subterraneous explosions; and adds to his list several others, formed in the same manner. In one of which he relates that fish in great abundance were found, and that all those who eat of them died shortly after.

"On the twenty-fourth of May,† in the year 1707, a slight earthquake was perceived at Santorin; and the day following, at sun-rising, an object was seen by the inhabitants of that island, at two or three miles distance at sea, which appeared like a floating rock. Some persons, desirous either of gain, or excited by curiosity, went there, and found, even while they stood

* Buffon, vol. ii. p. 343.

† Hist. de l'Acad. an. 1708, p. 23.

upon this rock, that it seemed to rise beneath their feet. They perceived also that its surface was covered with pumice stones and oysters, which it had raised from the bottom. Every day after, until the fourteenth of June, this rock seemed considerably to increase; and then was found to be half a mile round, and about thirty feet above the sea. The earth of which it was composed seemed whitish, with a small portion of clay. Soon after this the sea again appeared troubled, and steams arose, which were very offensive to the inhabitants of Santorin. But on the sixteenth of the succeeding month, seventeen or eighteen rocks more were seen to rise out of the sea, and at length to join together. All this was accompanied with the most terrible noise, and fires which proceeded from the island that was newly formed. The whole mass, however, of all this new-formed earth, uniting, increased every day, both in height and breadth, and by the force of its explosions, cast forth rocks to seven miles distance. This continued to bear the same dreadful appearances till the month of November in the same year; and it is at present a volcano which sometimes renews its explosions. It is about three miles in circumference; and more than from thirty-five to forty feet high."

It seems extraordinary, that, about this place in particular, islands have appeared at different times, particularly that of Hiera, mentioned above, which has received considerable additions in succeeding ages. Justin * tell us, that, at the time

* Justin, lib. 30. cap. 4.

the Macedonians were at war with the Romans, a new island appeared between those of Theramens and Therasia, by means of an earthquake. We are told, that this became half as big again about a thousand years after; another island rising up by its side, and joining to it, so as scarcely at present to be distinguished from the former.

A new island was formed, in the year 1720, near that of Tercera, near the continent of Africa, by the same causes. In the beginning of December, at night, there was a terrible earthquake at that place, and the top of a new island appeared, which cast forth smoke in vast quantities. The pilot of a ship, who approached it, sounded on one side of this island, and could not find ground at sixty fathom. At the other side the sea was totally tinged of a different colour, exhibiting a mixture of white, blue, and green; and was very shallow. This island, on its first appearance, was larger than it is at present; for it has, since that time, sunk in such a manner, as to be scarcely above water.*

[* In the spring of 1783, a volcanic island was formed in the vicinity of Iceland; which, according to the accounts of the navigators who that year visited the country, attracted no small notice. The discoverer, Captain Von Lowenhorn, in the Danish service, who arrived just at the time of the first eruption, when smoke and flames ascended out of the sea, relates that no island or any land could be seen, from which these flames could originate. No wonder, then, that he fell into the greatest consternation, when, as he expresses himself, he saw the waves on fire. The captain and crew, therefore, conceived the notion that the day of judgment was at hand, and took to their prayer and hymn books, devoutly to prepare themselves for their approach-

A traveller, whom these appearances could not avoid affecting, speaks of them in this manner: "* What can be more surprising than to see fire not only break out of the bowels of the earth, but also to make itself a passage through the waters of the sea! What can be more extraordinary or foreign to our common notions of things, than to see the bottom of the sea rise up into a mountain above the water, and become so firm an island, as to be able to resist the violence of the greatest storms! I know that subterraneous fires, when pent in a narrow passage, are able to raise up a mass of earth as large as an island. But that this should be done in so regular and

ing end. But as no trumpet sounded, as the sun remained undarkened, and the firmament undisturbed, they began to reflect farther what it might be; and at last hit upon the thought that Iceland had been sunk by an earthquake, and that this was the last remains and ejection of Hecla, the well-known burning mountain upon that island. Wholly possessed with this idea, they were on the point of tacking about, and returning to Denmark with the news of the dreadful event; but, luckily, they had not proceeded far before they got sight of the coast of Iceland.

The site of the volcanic eruption lies only $7\frac{3}{4}$ nautical miles, (15 to a degree) from the south-west point of Iceland; and as there are numerous instances of such volcanic eruptions becoming an island, the Danish government directed, the following year, that all ships bound to Iceland should examine the new-formed island; but so entirely had it vanished, that none of them either saw or could discover the smallest trace of it. However, towards the end of the next year, a Danish ship of war, of 64 guns, was wrecked on this rock; which is now no longer visible, but remains a most dangerous rock, nearly level with the surface of the water.]

* Phil. Trans. vol. v. p. 197.

exact a manner that the water of the sea should not be able to penetrate and extinguish those fires; that, after having made so many passages, they should retain force enough to raise the earth; and, in fine, after having been extinguished, that the mass of earth should not fall down, or sink again with its own weight, but still remain in a manner suspended over the great arch below! This is what to me seems more surprising than any thing that has been related of Mount Ætna, Vesuvius, or any other volcano."

Such are his sentiments: however, there are few of these appearances any way more extraordinary than those attending volcanoes and earthquakes in general. We are not more to be surprised that inflammable substances should be found beneath the bottom of the sea, than at similar depths at land. These have all the force of fire giving expansion to air, and tending to raise the earth at the bottom of the sea, till it at length heaves above water. These marine volcanoes are not so frequent; for, if we may judge of the usual procedure of nature, it must very often happen that, before the bottom of the sea is elevated above the surface, a chasm is opened in it, and then the water pressing in, extinguishes the volcano before it has time to produce its effects. This extinction, however, is not effected without very great resistance from the fire beneath. The water, upon dashing into the cavern, is very probably at first ejected back with great violence; and thus some of those amazing waterspouts are seen, which have so often asto-

nished the mariner, and excited curiosity.—But of these in their place.

Besides the production of those islands by the action of fire, there are others, as was said, produced by rivers or seas carrying mud, earth, and such like substances, along with their currents; and at last depositing them in some particular place. At the mouths of most great rivers, there are to be seen banks, thus formed by the sand and mud carried down with the stream, which have rested at that place, where the force of the current is diminished by its junction with the sea. These banks, by slow degrees, increase at the bottom of the deep; the water in those places is at first found by mariners to grow more shallow; the bank soon heaves up above the surface; it is considered, for a while, as a tract of useless and barren sand; but the seeds of some of the more hardy vegetables are driven thither by the wind, take root, and thus binding the sandy surface, the whole spot is clothed in time with a beautiful verdure. In this manner there are delightful and inhabited islands at the mouths of many rivers, particularly the Nile, the Po, the Mississippi, the Ganges, and the Senegal. There has been, in the memory of man, a beautiful and large island formed in this manner, at the mouth of the river Nanquin, in China, made from the depositions of mud at its opening; it is not less than sixty miles long, and about twenty broad. La Loubere informs us,* in his voyage to Siam,

* Lettres Curieuses et Edifiantes, sec. xi. p. 234.

that these sand-banks increase every day, at the mouths of all the great rivers in Asia; and hence he asserts, that the navigation up these rivers becomes every day more difficult, and will, at one time or another, be totally obstructed. The same may be remarked with regard to the Wolga, which has at present seventy openings into the Caspian Sea; and of the Danube, which has seven into the Euxine. We have had an instance of the formation of a new island, not very long since, at the mouth of the Humber, in England. "It is yet within the memory of man," says the relator,* "since it began to raise its head above the ocean. It began its appearance at low water, for the space of a few hours; and was buried again till the next tide's retreat. Thus, successively, it lived and died, until the year 1666, when it began to maintain its ground against the insult of the waves; and then first invited the aid of human industry. A bank was thrown about its rising grounds; and being thus defended from the incursions of the sea, it became firm and solid, and, in a short time, afforded good pasturage for cattle. It is about nine miles in circumference, and is worth to the proprietor about eight hundred pounds a year." It would be endless to mention all the islands that have been thus formed, and the advantages that have been derived from them. However, it is frequently found that new islands may often be considered as only turning the rivers from their former beds; so that,

* Phil. Trans. vol. iv. p. 251.

in proportion as land is gained at one part, it is lost by the overflowing of some other.

Little, therefore, is gained by such accession; nor is there much more by the new islands which are sometimes formed from the spoils of the continent. Mariners assure us, that there are sometimes whole plains unrooted from the main lands, by floods and tempests. These being carried out to sea, with all their trees and animals upon them, are frequently seen floating in the ocean, and exhibiting a surprising appearance of rural tranquillity in the midst of danger. The greatest part, however, having the earth at their roots at length washed away, are dispersed, and their animals drowned; but now and then some are found to brave the fury of the ocean, till being struck either among rocks or sands, they again take firm footing, and become permanent islands.

As different causes have thus concurred to produce new islands, so we have accounts of others that the same causes have contributed to destroy. We have already seen the power of earthquakes exerted in sinking whole cities, and leaving lakes in their room. There have been islands, and regions also, that have shared the same fate; and have sunk with their inhabitants, never more to be heard of. Thus Pausanias* tells us of an island, called Chryses, that was sunk near Lemnos. Pliny mentions several; among others, the island Cea, for thirty miles, having been washed away, with several thousands of its inhabitants.

* Pausanias, lib. 8, in Arcad. p. 509.

But of all the noted devastations of this kind, the total submersion of the island of Atalantis, as mentioned by Plato, has been most the subject of speculation. Mankind, in general, now consider the whole of his account as an ingenious fable; but when fables are grown famous by time and authority, they become an agreeable, if not a necessary part of literary information.

"About nine thousand years are passed," says Plato,* "since the island of Atalantis was in being. The priests of Egypt were well acquainted with it; and the first heroes of Athens gained much glory in their wars with the inhabitants. This island was as large as Asia Minor and Syria united; and was situated beyond the pillars of Hercules, in the Atlantic ocean. The beauty of the buildings, and the fertility of the soil, were far beyond any thing a modern imagination can conceive; gold and ivory were every where common, and the fruits of the earth offered themselves without cultivation. The arts, and the courage of the inhabitants, were not inferior to the happiness of their situation; and they were frequently known to make conquests, and over-run the continent of Europe and Asia." The imagination of the poetical philosopher riots in the description of the natural and acquired advantages, which they long enjoyed in this charming region. "If," says he, "we compare that country to our own, ours will appear a mere wasted skeleton, when opposed to it. Their mountains, to the very tops,

* Plato in Critia.

were clothed with fertility, and poured down rivers to enrich the plains below."

However, all these beauties and benefits were destroyed in one day by an earthquake sinking the earth, and the sea overwhelming it. At present, not the smallest vestiges of such an island are to be found; Plato remains as the only authority for its existence, and philosophers dispute about its situation. It is not for me to enter into the controversy, when there appears but little probability to support the fact; and, indeed, it would be useless to run back nine thousand years in search of difficulties, as we are surrounded with objects that more closely affect us, and that demand admiration at our very doors. When I consider, as Lactantius suggests, the various vicissitudes of nature; lands swallowed by yawning earthquakes, or overwhelmed in the deep; rivers and lakes disappearing, or dried away; mountains levelled into plains; and plains swelling up into mountains;—I cannot help regarding this earth as a place of very little stability; as a transient abode of still more transitory beings.

CHAP. XII.

Of Mountains.

HAVING at last, in some measure, emerged from the deeps of the earth, we come to a scene of greater splendour; the contemplation of its external appearance. In this survey, its moun-

tains are the first objects that strike the imagination, and excite our curiosity. There is not, perhaps, any thing in all nature that impresses an unaccustomed spectator with such ideas of awful solemnity, as these immense piles of nature's erecting, that seem to mock the minuteness of human magnificence.

In countries where there are nothing but plains, the smallest elevations are apt to excite wonder. In Holland, which is all a flat, they show a little ridge of hills, near the sea-side, which Boerhaave generally marked out to his pupils as being mountains of no small consideration. What would be the sensations of such an auditory, could they at once be presented with a view of the heights and precipices of the Alps, or the Andes? Even among us, in England, we have no adequate ideas of a mountain-prospect; our hills are generally sloping from the plain, and clothed to the very top with verdure. We can scarcely, therefore, lift our imaginations to those immense piles whose tops peep up behind intervening clouds, sharp and precipitate, and reach to heights that human avarice or curiosity have never been able to ascend.

We, in this part of the world, are not, for that reason, so immediately interested in the question which has so long been agitated among philosophers, concerning what gave rise to these inequalities on the surface of the globe. In our own happy region, we generally see no inequalities but such as contribute to use and beauty; and we therefore are amazed at a question inquiring how such necessary inequalities came to be formed, and seeming to express a wonder how the globe

comes to be so beautiful as we find it. But though with us there may be no great cause for such a demand, yet in those places where mountains deform the face of Nature, where they pour down cataracts, or give fury to tempests, there seems to be good reason for inquiry either into their causes or their uses. It has been, therefore, asked by many in what manner mountains have come to be formed, or for what uses they are designed?

To satisfy curiosity in these respects, much reasoning has been employed, and very little knowledge propagated. With regard to the first part of the demand, the manner in which mountains were formed, we have already seen the conjectures of different philosophers on that head. One supposing that they were formed from the earth's broken shell, at the time of the deluge: another, that they existed from the creation, and only acquired their deformities in process of time: a third, that they owed their original to earthquakes: and still a fourth, with much more plausibility than the rest, ascribing them entirely to the fluctuations of the deep, which he supposes, in the beginning, to have covered the whole earth. Such as are pleased with disquisitions of this kind, may consult Burnet, Whiston, Woodward, or Buffon. Nor would I be thought to decry any mental amusements, that at worst keep us innocently employed; but, for my own part, I cannot help wondering how the opposite demand has never come to be made; and why philosophers have never asked how we come to have plains? Plains are sometimes more prejudicial to man than mountains. Upon plains, an inundation has greater power; the beams of the

sun are often collected there with suffocating fierceness; they are sometimes found desert for several hundred miles together, as in the country east of the Caspian sea, although otherwise fruitful, merely because there are no risings nor depressions to form reservoirs, or collect the smallest rivulet of water. The most rational answer, therefore, why either mountains or plains were formed, seems to be, that they were thus fashioned by the hand of Wisdom, in order that pain and pleasure should be so contiguous, as that morality might be exercised either in bearing the one, or communicating the other.

Indeed, the more I consider this dispute respecting the formation of mountains, the more I am struck with the futility of the question. There is neither a straight line, nor an exact superficies, in all nature. If we consider a circle, even with mathematical precision, we shall find it formed of a number of small right lines, joining at angles together. These angles, therefore, may be considered in a circle as mountains are upon our globe; and to demand the reason for the one being mountainous, or the other angular, is only to ask why a circle is a circle, or a globe is a globe. In short, if there be no surface without inequality in Nature, why should we be surprised that the earth has such? It has often been said, that the inequalities of its surface are scarcely distinguishable, if compared to its magnitude; and I think we have every reason to be content with the answer.

Some, however, have avoided the difficulty by urging the final cause. They allege that mountains have been formed merely because they are useful to man. This carries the inquirer but a part

of the way; for no one can affirm that in all places they are useful. The contrary is known, by horrid experience, in those vallies that are subject to their influence. However, as the utility of any part of our earthly habitation is a very pleasing and flattering speculation to every philosopher, it is not to be wondered that much has been said to prove the usefulness of these. For this purpose, many conjectures have been made that have received a degree of assent even beyond their evidence; for men were unwilling to become more miserably wise.

It has been alleged, as one principal advantage that we derive from them, that they serve, like hoops or ribs, to strengthen our earth, and to bind it together. In consequence of this theory, Kircher has given us a map of the earth, in this manner hooped with its mountains; which might have a much more solid foundation, did it entirely correspond with truth.

Others have found a different use for them, especially when they run surrounding our globe, which is, that they stop the vapours which are continually travelling from the equator to the poles; for these being urged by the heat of the sun, from the warm regions of the line, must all be accumulated at the poles, if they were not stopped in their way by those high ridges of mountains which cross their direction. But an answer to this may be, that all the great mountains in America, lie lengthwise, and therefore do not cross their direction.

But to leave these remote advantages, others assert, that not only the animal but vegetable part

of the creation would perish for want of convenient humidity, were it not for their friendly assistance. Their summits are, by these, supposed to arrest, as it were, the vapours which float in the regions of the air. Their large inflexions, and channels, are considered as so many basons prepared for the reception of those thick vapours, and impetuous rains, which descend into them. The huge caverns beneath are so many magazines or conservatories of water for the peculiar service of man: and those orifices by which the water is discharged upon the plain, are so situated as to enrich and render them fruitful, instead of returning through subterraneous channels to the sea, after the performance of a tedious and fruitless circulation.*

However this be, certain it is that almost all our great rivers find their source among mountains; and, in general, the more extensive the mountain, the greater the river: thus the river Amazon, the greatest in the world, has its source among the Andes, which are the highest mountains on the globe; the river Niger travels a long course of several hundred miles from the mountains of the Moon, the highest in all Africa; and the Danube and the Rhine proceed from the Alps, which are probably the highest mountains of Europe.

It need scarcely be said that, with respect to height, there are many sizes of mountains, from the gently rising upland, to the tall craggy precipice. The appearance is in general different in

* Nature Displayed, vol. iii. p. 88.

those of different magnitudes. The first are clothed with verdure to the very tops, and only seem to ascend to improve our prospects, or supply us with a purer air: but the lofty mountains of the other class have a very different aspect. At a distance their tops are seen, in wavy ridges, of the very colour of the cloud, and only to be distinguished from them by their figure, which, as I have said, resembles the billows of the sea.* As we approach, the mountain assumes a deeper colour; it gathers upon the sky, and seems to hide half the horizon behind it. Its summits also are become more distinct, and appear with a broken and perpendicular line. What at first seemed a single hill, is now found to be a chain of continued mountains, whose tops, running along in ridges, are embosomed in each other; so that the curvatures of one are fitted to the prominences of the opposite side, and form a winding valley between, often of several miles in extent; and all the way continuing nearly of the same breadth.

Nothing can be finer, or more exact, than Mr. Pope's description of a traveller straining up the Alps. Every mountain he comes to he thinks will be the last; he finds, however, an unexpected hill rise before him; and that being scaled, he finds the highest summit almost at as great a distance as before. Upon quitting the plain, he might have left a green and a fertile soil, and a climate warm and pleasing. As he ascends, the ground assumes a more russet colour; the grass becomes more mossy, and the weather more moderate. Still as

* Lettres Philosophiques sur la Formation, &c. p. 106.

he ascends, the weather becomes more cold, and the earth more barren. In this dreary passage, he is often entertained with a little valley of surprising verdure, caused by the reflected heat of the sun collected into a narrow spot on the surrounding heights. But it much more frequently happens that he sees only frightful precipices beneath, and lakes of amazing depths; from whence rivers are formed, and fountains derive their original. On those places next the highest summits, vegetation is scarcely carried on; here and there a few plants of the most hardy kind appear. The air is intolerably cold; either continually refrigerated with frosts, or disturbed with tempests. All the ground here wears an eternal covering of ice, and snows that seem constantly accumulating. Upon emerging from this war of the elements, he ascends into a purer and a serener region, where vegetation is entirely ceased; where the precipices, composed entirely of rocks, rise perpendicularly above him; while he views beneath him all the combat of the elements; clouds at his feet; and thunders darting upwards from their bosoms below.* A thousand meteors, which are never seen on the plain, present themselves. Circular rainbows;† mock suns; the shadow of the mountain projected upon the body of the air; ‡ and the traveller's own image, reflected as in a looking-glass, upon the opposite cloud. ||

Such are, in general, the wonders that present themselves to a traveller in his journey either over the Alps or the Andes. But we must not suppose

* Ulloa, vol. i. † Ibid. ‡ Phil. Trans. vol. v. p. 152.
|| Ulloa, vol. I.

that this picture exhibits either a constant or an invariable likeness of those stupendous heights. Indeed, nothing can be more capricious or irregular than the forms of many of them. The tops of some run in ridges for a considerable length, without interruption; in others the line seems indented by great vallies to an amazing depth. Sometimes a solitary and a single mountain rises from the bosom of the plain; and sometimes extensive plains, and even provinces, as those of Savoy and Quito, are found embosomed near the tops of mountains. In general, however, those countries that are most mountainous, are the most barren and uninhabitable.

If we compare the heights of mountains with each other, we shall find that the greatest and highest are found under the line.* It is thought by some, that the rapidity of the earth's motion in these parts, together with the greatness of the tides there, may have thrown up those stupendous masses of earth. But, be the cause as it may, it is a remarkable fact, that the inequalities of the earth's surface are greatest there. Near the Poles, the earth, indeed, is craggy and uneven enough; but the heights of the mountains there are very inconsiderable. On the contrary, at the Equator, where Nature seems to sport in the amazing size of all her productions, the plains are extensive, and the mountains remarkably lofty. Some of them are known to rise three miles perpendicular above the bed of the ocean.

To enumerate the most remarkable of these, ac-

* Buffon, passim.

according to their size, we shall begin with the Andes, of which we have an excellent description by Ulloa, who went thither by command of the king of Spain, in company with the French Academicians, to measure a degree of the meridian. His journey up these mountains is too curious not to give an extract from.

After many incommodious days sailing up the river Guayaquil, he arrived at Caracol, a town situated at the foot of the Andes. Nothing could exceed the inconveniences which he experienced in this voyage, from the flies and moschetoes (an animal resembling our gnat). "We were the whole day," says he, "in continual motion to keep them off; but at night our torments were excessive. Our gloves, indeed, were some defence to our hands; but our faces were entirely exposed; nor were our clothes a sufficient defence for the rest of our bodies; for their stings penetrating through the cloth, caused a very painful and fiery itching. One night, in coming to an anchor near a large and handsome house that was uninhabited, we had no sooner seated ourselves in it, than we were attacked on all sides by swarms of moschetoes, so that it was impossible to have one moment's quiet. Those who had covered themselves with clothes made for this purpose, found not the smallest defence; wherefore, hoping to find some relief in the open fields, we ventured out, though in danger of suffering in a more terrible manner from the serpents. But both places were equally obnoxious. On quitting this inhospitable retreat, we the next night took up our quarters in a house that was inhabited; the

host of which, being informed of the terrible manner we had passed the night before, gravely told us, that the house we so greatly complained of, had been forsaken on account of its being the purgatory of a soul. But we had more reason to believe that it was quitted on account of its being the purgatory of the body. After having journeyed for upwards of three days, through boggy roads, in which the mules at every step sunk up to their bellies, we began at length to perceive an alteration in the climate; and having been long accustomed to heat, we now began to feel it grow sensibly colder.

" It is remarkable, that at Tariguagua we often see instances of the effects of two opposite temperatures, in two persons happening to meet; one of them leaving the plains below, and the other descending from the mountain. The former thinks the cold so severe, that he wraps himself up in all the garments he can procure; while the latter finds the heat so great, that he is scarcely able to bear any clothes whatsoever. The one thinks the water so cold, that he avoids being sprinkled by it; the other is so delighted with its warmth, that he uses it as a bath. Nor is the case very different in the same person, who experiences the same diversity of sensation upon his journey up, and upon his return. This difference only proceeds from the change naturally felt at leaving a climate to which one has been accustomed, and coming into another of an opposite temperature.

" The ruggedness of the road from Tariguagua, leading up the mountain, is not easily de-

scribed. In some parts the declivity is so great, that the mules can scarcely keep their footing; and in others, the acclivity is equally difficult. The trouble of having people going before to mend the road, the pains arising from the many falls and bruises, and the being constantly wet to the skin, might be supported, were not these inconveniences augmented by the sight of such frightful precipices, and deep abysses, as must fill the mind with ceaseless terror. There are some places were the road is so steep, and yet so narrow, that the mules are obliged to slide down, without making any use of their feet whatsoever. On one side of the rider, in this situation, rises an eminence of several hundred yards; and on the other, an abyss of equal depth; so that if he in the least checks his mule, so as to destroy the equilibrium, they both must unavoidably perish.

"After having travelled about nine days in this manner, slowly winding along the side of the mountain, we began to find the whole country covered with a hoar frost; and a hut in which we lay had ice on it. Having escaped many perils, we at length, after a journey of fifteen days, arrived upon the plain, on the extremity of which stands the city of Quito, the capital of one of the most charming regions upon earth. Here, in the centre of the torrid zone, the heat is not only very tolerable, but in some places the cold also is painful. Here they enjoy all the temperature and advantages of perpetual spring; their fields being always covered with verdure, and enamelled with flowers of the

most lively colours. However, although this beautiful region be higher than any other country in the world, and although it took up so many days of painful journey in the ascent, it is still overlooked by tremendous mountains; their sides covered with snow, and yet flaming with volcanoes at the top. These seem piled one upon the other, and rise to a most astonishing height, with great coldness. However, at a determined point above the surface of the sea, the congelation is found at the same height in all the mountains. Those parts which are not subject to a continual frost, have here and there growing upon them a rush, resembling the genista, but much more soft and flexible. Towards the extremity of the part where the rush grows, and the cold begins to increase, is found a vegetable, with a round bulbous head, which, when dried, becomes of amazing elasticity. Higher up, the earth is entirely bare of vegetation, and seems covered with eternal snow. The most remarkable mountains are, that of Cotopaxi, (already described as a volcano) Chimborazo, and Pichincha. Cotopaxi is more than three geographical miles above the surface of the sea: the rest are not much inferior. On the top of the latter was my station for measuring a degree of the meridian; where I suffered particular hardships, from the intenseness of the cold, and the violence of the storms. The sky around was, in general, involved in thick fogs, which, when they cleared away, and the clouds, by their gravity, moved nearer to the surface of the earth, they appeared surrounding the foot of the

mountain, at a vast distance below, like a sea, encompassing an island in the midst of it. When this happened, the horrid noises of tempests were heard from beneath, then discharging themselves on Quito, and the neighbouring country. I saw the lightnings issue from the clouds, and heard the thunders roll far beneath me. All this time, while the tempest was raging below, the mountain top, where I was placed, enjoyed a delightful serenity; the wind was abated; the sky clear; and the enlivening rays of the sun moderated the severity of the cold. However, this was of no very long duration, for the wind returned with all its violence, and with such velocity as to dazzle the sight; whilst my fears were increased by the dreadful concussions of the precipice, and the fall of enormous rocks; the only sounds that were heard in this frightful situation."

Such is the animated picture of these mountains, as given us by this ingenious Spaniard: and I believe the reader will wish that I had made the quotation still longer. A passage over the Alps, or a journey across the Pyrenees, appear petty trips or excursions, in the comparison; and yet these are the most lofty mountains we know of in Europe.

If we compare the Alps with the mountains already described, we shall find them but little more than one half of the height of the former. The Andes, upon being measured by the barometer, are found above three thousand one hundred and thirty-six toises or fathoms above the surface of the sea.* Whereas the highest

* Ulloa, vol. i. p. 442.

point of the Alps is not above sixteen hundred. The one, in other words, is above three miles high; the other about a mile and a half. The highest mountains in Asia are, Mount Taurus, Mount Immaus, Mount Caucasus, and the mountains of Japan. Of these, none equals the Andes in height; although Mount Caucasus, which is the highest of them, makes very near approaches. Father Verbiest tells of a mountain in China, which he measured, and found a mile and a half high.* In Africa, the mountains of the Moon, famous for giving source to the Niger and the Nile, are rather more noted than known. Of the Peak of Teneriffe, one of the Canary Islands that lie off this coast, we have more certain information. In the year 1727, it was visited by a company of English merchants, who travelled up to the top, where they observed its height, and the volcano on its very summit.† They found it a heap of mountains, the highest of which rises over the rest like a sugar-loaf, and gives a name to the whole mass. It is computed to be a mile and a half perpendicular from the surface of the sea. Kircher gives us an estimate of the heights of most of the other great mountains in the world; but as he has taken his calculations, in general, from the ancients; or from modern travellers, who had not the art of measuring them, they are quite incredible. The art of taking the heights of places by the barometer is a new and an ingenious invention. As the air grows lighter as we ascend,

* Verbiest, à la Chine. † Phil. Trans. vol. v.

the fluid in the tube rises in due proportion; thus the instrument being properly marked, gives the height with a tolerable degree of exactness; at least enough to satisfy curiosity.

Few of our great mountains have been estimated in this manner; travellers having, perhaps, been deterred, by a supposed impossibility of breathing at the top. However, it has been invariably found, that the air in the highest that our modern travellers have ascended, is not at all too fine for respiration. At the top of the Peak of Teneriffe, there was found no other inconvenience from the air, except its coldness; at the top of the Andes there was no difficulty of breathing perceived. The accounts, therefore, of those who have asserted that they were unable to breathe, although at much less heights, are greatly to be suspected. In fact, it is very natural for mankind to paint those obstacles as insurmountable, which they themselves have not had the fortitude or perseverance to surmount.

The difficulty and danger of ascending to the tops of mountains, proceeds from other causes, not the thinness of the air. For instance, some of the summits of the Alps have never yet been visited by man; but the reason is, that they rise with such a rugged and precipitate ascent, that they are utterly inaccessible. In some places they appear like a great wall of six or seven hundred feet high; in others there stick out enormous rocks, that hang upon the brow of the steep, and every moment threaten destruction to the traveller below.

In this manner almost all the tops of the

highest mountains are bare and pointed. And this naturally proceeds from their being so continually assaulted by thunders and tempests. All the earthy substances with which they might have been once covered, have for ages been washed away from their summits; and nothing is left remaining, but immense rocks, which no tempest has hitherto been able to destroy.

Nevertheless, time is every day, and every hour, making depredations; and huge fragments are seen tumbling down the precipice, either loosened from the summit by frost or rains, or struck down by lightning. Nothing can exhibit a more terrible picture than one of these enormous rocks, commonly larger than a house, falling from its height, with a noise louder than thunder, and rolling down the side of the mountain. Dr. Plot tell us of one in particular, which being loosened from its bed, tumbled down the precipice, and was partly shattered into a thousand pieces. Notwithstanding, one of the largest fragments of the same, still preserving its motion, travelled over the plain below, crossed a rivulet in the midst, and at last stopped on the other side of the bank! These fragments, as was said, are often struck off by lightning, and sometimes undermined by rains; but the most usual manner in which they are disunited from the mountain, is by frost: the rains insinuating between the interstices of the mountain, continue there until there comes a frost, and then, when converted into ice, the water swells with an irresistible force, and produces the same effect as gun-powder, splitting the most solid rocks, and thus shattering the summits of the mountain.

But not rocks alone, but whole mountains are, by various causes, disunited from each other. We see in many parts of the Alps, amazing clefts, the sides of which so exactly correspond with the opposite, that no doubt can be made of their having been once joined together. At Cajeta,* in Italy, a mountain was split in this manner by an earthquake; and there is a passage opened through it, that appears as if elaborately done by the industry of man. In the Andes these breaches are frequently seen.— That at Thermopylæ, in Greece, has been long famous. The mountain of the Troglodytes, in Arabia, has thus a passage through it: and that in Savoy, which nature began, and which Victor Amadeus completed, is an instance of the same kind.

We have accounts of some of these disruptions, immediately after their happening. "In the month of June,† in the year 1714, a part of the mountain of Diableret, in the district of Valais, in France, suddenly fell down, between two and three o'clock in the afternoon, the weather being very calm and serene. It was of a conical figure, and destroyed fifty-five cottages in the fall. Fifteen persons, together with about a hundred beasts, were also crushed beneath its ruins, which covered an extent of a good league square. The dust it occasioned instantly covered all the neighbourhood in darkness. The heaps of rubbish were more than three hundred feet high. They stopped the current of a river that ran along the plain,

* Buffon, vol. ii. p. 364.

† Hist. de l'Académie des Sciences, p. 4. an. 1715.

which is now formed into several new and deep lakes. There appeared, through the whole of this rubbish, none of those substances that seemed to indicate that this disruption had been made by means of subterraneous fires. Most probably, the base of this rocky mountain was rotted and decayed; and thus fell without any extraneous violence." In the same manner, in the year 1618, the town of Pleurs, in France, was buried beneath a rocky mountain, at the foot of which it was situated.

These accidents, and many more that might be enumerated of the same kind, have been produced by various causes: by earthquakes, as in the mountain at Cajeta; or by being decayed at the bottom, as at Diableret. But the most general way is, by the foundation of one part of the mountain being hollowed by waters, and thus, wanting a support, breaking from the other. Thus it generally has been found in the great chasms in the Alps; and thus it almost always is known in those disruptions of hills, which are known by the name of land-slips. These are nothing more than the slidings down of a higher piece of ground, disrooted from its situation by subterraneous inundations, and settling itself upon the plain below.

There is not an appearance in all nature that so much astonished our ancestors, as these land-slips. In fact, to behold a large upland, with its houses, its corn, and cattle, at once loosened from its place, and floating, as it were, upon the subjacent water; to behold it quitting its ancient situation, and travelling forward like a ship, in quest of new adventures; this is certainly one of the most ex-

traordinary appearances that can be imagined; and to a people ignorant of the powers of Nature, might well be considered as a prodigy. Accordingly, we find all our old historians mentioning it as an omen of approaching calamities. In this more enlightened age, however, its cause is very well known; and, instead of exciting ominous apprehensious in the populace, it only gives rise to some very ridiculous law-suits among them, about whose the property shall be; whether the land which has thus slipt, shall belong to the original possessor, or to him upon whose grounds it has encroached and settled. What has been the determination of the judges, is not so well known; but the circumstances of the slips have been minutely and exactly described.

In the lands of Slatberg,* in the kingdom of Iceland, there stood a declivity, gradually ascending for near half a mile. In the year 1713, and on the 10th of March, the inhabitants perceived a crack on its side, somewhat like a furrow made with a plough, which they imputed to the effects of lightning, as there had been thunder the night before. However, on the evening of the same day, they were surprised to hear a hideous confused noise issuing all round from the side of the hill; and their curiosity being raised, they resorted to the place. There, to their amazement, they found the earth, for near five acres, all in gentle motion, and sliding down the hill upon the subjacent plain. This motion continued the remaining part of the day and the whole night; nor did the noise cease

* Phil. Trans. vol. iv. p. 250.

during the whole time; proceeding, probably, from the attrition of the ground beneath. The day following, however, this strange journey down the hill ceased entirely; and above an acre of the meadow below was found covered with what before composed a part of the declivity.

However, these slips, when a whole mountain's side seems to descend, happen but very rarely. There are some of another kind, however, much more common; and, as they are always sudden, much more dangerous. These are snow-slips, well known, and greatly dreaded by travellers. It often happens, that when snow has long been accumulated on the tops and on the sides of mountains, it is borne down the precipice, either by means of tempests, or its own melting. At first, when loosened, the volume in motion is but small, but gathers as it continues to roll; and, by the time it has reached the habitable parts of the mountain, is generally grown of enormous bulk. Wherever it rolls it levels all things in its way, or buries them in unavoidable destruction. Instead of rolling, it sometimes is found to slide along from the top; yet even thus it is generally as fatal as before. Nevertheless, we have had an instance, a few years ago, of a small family in Germany, that lived for above a fortnight beneath one of these snow-slips. Although they were buried, during that whole time, in utter darkness, and under a bed of some hundred feet deep, yet they were luckily taken out alive; the weight of the snow being supported by a beam that kept up the roof; and nourishment being supplied them by the milk

of an ass, if I remember right, that was buried under the same ruin.*

But it is not the parts, alone, that are thus found to subside; whole mountains have been known to-

[* A well authenticated case of a woman surviving nearly eight days, buried in the snow, without food, occurred near Impington, in Cambridgeshire; and is related by Mr. Okes, the surgeon who attended her, in the annals of medicine for the year 1799.

Elizabeth Woodcock, aged 42, of a slender, delicate make, on her return from Cambridge, on the evening of the second of February, being exhausted with running after her horse which had started from her, and becoming numbed in the hands and feet, sat down on the ground. At that time a small quantity of snow had but drifted near her, but it began to accumulate very rapidly; and when Chesterton bells had rang at eight o'clock, she was completely inclosed and penned in by it. To the best of her recollection, she slept very little during the first night.— On the morning of the third, observing before her a circular hole in the snow, about two feet in length and half a foot in diameter, running obliquely upwards, and closed with a thin covering of ice or snow, she broke off a branch of a bush that was close to her, and with it thrust her handkerchief through the hole, as a signal of distress.

In consequence of the external air being admitted, she felt herself very cold. On the second morning of her imprisonment, the hole was again closed up, and continued so till the third day, after which time it remained open. She heard distinctly the ringing of the village bells, noises on the highway, and even the conversation of some gypsies who passed near her, but could not make herself heard. She easily distinguished day and night, could even read an almanack she took from her pocket. The sensation of hunger ceased almost entirely after the first day.— Thirst was throughout her predominant feeling; and this she had the plentiful means of allaying, by sucking the surrounding snow. She felt no gratification from the use of her snuff. On Friday the eighth, when a thaw took place, she felt uncommonly faint and languid: her clothes were wet quite through by

tally to disappear. Pliny* tells us, that in his own time, the lofty mountain of Cybotus, together with the city of Eurites, were swallowed by an earthquake. The same fate, he says, attended Phlegium, one of the highest mountains in Æthiopia; which, after one night's concussion, was never seen more. In more modern times, a very noted mountain in the Molucca islands, known by the name of the Peak, and remarkable for being seen at a very great distance from sea,

the melted snow; and the aperture became enlarged, and tempted her in vain to attempt to disengage herself.

On Sunday the 10th, a little after mid-day, she was discovered. A piece of biscuit and a small quantity of brandy were given her, from which she found herself greatly recruited; but she was so much exhausted, that, on being lifted into the chaise, she fainted.

Mr. Okes saw her that day on her way home: he found her hands and arms sodden, but not very cold, and her pulse did not indicate the great debility which might have been expected: her legs were cold, and her feet in a great measure mortified. She was directed to be put into bed without delay, and to take some weak broth occasionally, but no strong liquors, and not to be brought near the fire. Next day she was affected with symptoms of fever; her pulse was rising, her face was flushed, and her breathing short; occasioned probably by having taken too much food, and being incommoded by the crowd of visitors. Her feet were also in a complete state of mortification, her ancles cold and benumbed, and the integuments puffy. Cloths wetted with brandy were applied to her feet, some antifebrile remedies and a little opium were given her. The mortification, however, proceeded, and, on the 17th of March, all the toes were removed, and the bones of the heels were bare in many parts; on the 17th of April, the date of the last report, the sores were free from sloughs, and diminishing daily in size; her appetite was becoming tolerably good, and her health was improving.]

* Plin. lib. ii. cap. 93.

was swallowed by an earthquake; and nothing but a lake was left in the place where it stood.—Thus, while storms and tempests are levelled against mountains above, earthquakes and waters are undermining them below. All our histories talk of their destruction; and very few new ones (if we except Mount Cenere, and one or two such heaps of cinders) are produced. If mountains, therefore, were of such great utility as some philosophers make them to mankind, it would be a very melancholy consideration that such benefits were diminishing every day. But the truth is, the valleys are fertilized by that earth which is washed from their sides; and the plains become richer, in proportion as the mountains decay.

CHAP. XIII.

Of Water.

IN contemplating Nature, we shall often find the same substances possessed of contrary qualities, and producing opposite effects. Air, which liquefies one substance, dries up another. That fire which is seen to burn up the desert, is often found, in other places, to assist the luxuriance of vegetation; and water, which, next to fire, is the most fluid substance upon earth, nevertheless gives all other bodies their firmness and durability; so that every element seems to be a powerful servant, capable either of good or ill, and only awaiting external direction, to become the friend or the enemy of mankind. These opposite quali-

ties, in this substance in particular, have not failed to excite the admiration and inquiry of the curious.

That water is the most fluid penetrating body, next to fire, and the most difficult to confine, is incontestably proved by a variety of experiments. A vessel through which water cannot pass, may be said to retain any thing. It may be objected, indeed, that syrups, oils, and honey, leak through some vessels that water cannot pass through; but this is far from being the result of the greater tenuity and fineness of their parts; it is owing to the rosin wherewith the wood of such vessels abounds, which oils and syrups have a power of dissolving; so that these fluids, instead of finding their way, may more properly be said to eat their way through the vessels that contain them. However, water will at last find its way even through these; for it is known to escape through vessels of every substance, glass only excepted. Other bodies may be found to make their way out more readily indeed; as air, when it finds a vent, will escape at once; and quicksilver, because of its weight, quickly penetrates through whatever chinky vessel confines it: but water, though it operates more slowly, yet always finds a more certain issue. As, for instance, it is well known that air will not pass through leather; which water will very readily penetrate. Air also may be retained in a bladder; but water will quickly ooze through. And those who drive this to the greatest degree of precision, pretend to say, that it will pass through pores ten times smaller than air can do. Be this as it may, we are very certain that its parts are so

small that they have been actually driven through the pores of gold. This has been proved by the famous Florentine experiment, in which a quantity of water was shut up in a hollow ball of gold, and then pressed with a huge force by screws, during which the fluid was seen to ooze through the pores of the metal, and to stand, like a dew, upon its surface.

As water is thus penetrating, and its parts thus minute, it may easily be supposed that they enter into the composition of all bodies, vegetable, animal, and fossil. This every chemist's experience convinces him of; and the mixture is the more obvious, as it can always be separated, by a gentle heat, from those substances with which it had been united. Fire, as was said, will penetrate where water cannot pass; but then it is not so easily to be separated. But there is scarce any substance from which its water cannot be divorced. The parings or filings of lead, tin, and antimony, by distillation, yield water plentifully: the hardest stones, sea-salt, nitre, vitriol, and sulphur, are found to consist chiefly of water; into which they resolve by force of fire. "All birds, beasts, and fishes," says Newton, "insects, trees, and vegetables, with their parts, grow from water; and, by putrefaction, return to water again." In short, almost every substance that we see, owes its texture and firmness to the parts of water that mix with its earth; and, deprived of this fluid, becomes a mass of shapeless dust and ashes.

From hence we see, as was above hinted, that this most fluid body, when mixed with others, gives them consistence and form. Water, by

being mixed with earth or ashes, and formed into a vessel, when baked before the fire, becomes a coppel, remarkable for this, that it will bear the utmost force of the hottest furnace that art can contrive. So the Chinese earth, of which porcelain is made, is nothing more than an artificial composition of earth and water united by heat; and which a greater degree of heat could easily separate. Thus we see a body, extremely fluid of itself, in some measure assuming a new nature, by being united with others; we see a body, whose fluid and dissolving qualities are so obvious, giving consistence and hardness to all the substances of the earth.

From considerations of this kind, Thales, and many of the ancient philosophers, held that all things were made of water. In order to confirm this opinion, Helmont made an experiment, by divesting a quantity of earth of all its oils and salts, and then putting this earth, so prepared, into an earthen pot, which nothing but rain-water could enter, and planting a willow therein; this vegetable, so planted, grew up to a considerable height and bulk merely from the accidental aspersion of rain-water; while the earth in which it was planted received no sensible diminution. From this experiment, he concluded, that water was the only nourishment of the vegetable tribe; and that vegetables, being the nourishment of animals, all organized substances, therefore, owed their support and being only to water. But this has been said by Woodward to be a mistake: for he shows, that water being impregnated with earthy particles, is only the conveyer of such substances into the

pores of vegetables, rather than an increaser of them, by its own bulk: and likewise, that water is ever found to afford so much less nourishment, in proportion as it is purified by distillation. A plant in distilled water will not grow so fast as in water not distilled: and if the same be distilled three or four times over, the plant will scarcely grow at all, or receive any nourishment from it. So that water, as such, does not seem the proper nourishment of vegetables, but only the vehicle thereof, which contains the nutritious particles, and carries them through all parts of the plant. Water, in its pure state, may suffice to extend or swell the parts of a plant, but affords vegetable matter in a moderate proportion.

However this be, it is agreed, on all sides, that water, such as we find it, is far from being a pure, simple substance. The most genuine we know, is mixed with exhalations and dissolutions of various kinds; and no expedient that has been hitherto discovered, is capable of purifying it entirely. If we filter and distil it a thousand times, according to Boerhaave, it will still depose a sediment: and by repeating the process, we may evaporate it entirely away, but can never totally remove its impurities. Some, however, assert, that water, properly distilled, will have no sediment;* and that the little white speck which is found at the bottom of the still, is a substance that enters from without. Kircher used to show, in his Musæum, a phial of water, that had been kept for fifty years, hermetically

* Hill's History of Fossils.

sealed;* during which time it deposed no sediment, but continued as transparent as when first it was put in. How far, therefore, it may be brought to a state of purity by distillation, is unknown; but we very well know, that all such water as we every where see, is a bed in which plants, minerals, and animals, are all found confusedly floating together.

Rain-water, which is a fluid of Nature's own distilling, and which has been raised so high by evaporation, is, nevertheless, a very mixed and impure substance. Exhalations of all kinds, whether salts, sulphurs, or metals, make a part of its substance, and tend to increase its weight. If we gather the water that falls, after a thunder-clap, in a sultry summer's day, and let it settle, we shall find a real salt sticking at the bottom. In winter, however, its impure mixtures are fewer; but still may be separated by distillation. As to that which is generally caught pouring from the tops of houses, it is particularly foul, being impregnated with the smoke of the chimnies, the vapour of the slates or tiles, and with other impurities that birds and animals may have deposited there. Besides, though it should be supposed free from all these, it is mixed with a quantity of air, which, after being kept for some time, will be seen to separate.

Spring-water is next in point of purity. This, according to Doctor Halley, is collected from the

* Hermetically sealing a glass vessel, means no more than heating the mouth of the phial red hot; and thus, when the glass is become pliant, squeezing the mouth together with a pair of pincers, and then twisting it six or seven times round, which effectually closes it up.

air itself; which being sated with water, and coming to be condensed by the evening's cold, is driven against the tops of the mountains, where being condensed, and collected, it trickles down by the sides, into the cavities of the earth; and running for a while under-ground, bubbles up in fountains upon the plain. This having made but a short circulation, has generally had no long time to dissolve or imbibe any foreign substances by the way.

River-water is generally more foul than the former. Wherever the stream flows, it receives a tincture from its channel. Plants, minerals, and animals, all contribute to add to its impurities; so that such as live at the mouths of great rivers, are generally subject to all those disorders which contaminated and unwholesome waters are known to produce. Of all the river-water in the world, that of the Indus, and the Thames, are said to be most light and wholesome.

The most impure fresh water that we know, is that of stagnating pools and lakes, which, in summer, may be more properly considered as a jelly of floating insects, than a collection of water. In this, millions of little reptiles, undisturbed by any current, which might crush their frames to pieces, breed and engender. The whole teems with shapeless life, and only grows more fruitful by increasing putrefaction.*

[* Water is now known to be a compound substance, consisting of a mixture of oxygene or vital air, and hydrogene or inflammable air, in the proportion of about six parts of the former with one of the latter. When water is stagnant or quiescent, it becomes gradually decomposed by the greater warmth of

Of the purity of all these waters, the lightness, and not the the transparency, ought to be the test. Water may be extremely clear and beautiful to the eye, and yet very much impregnated with mineral particles. In fact, sea-water is the most transparent of any, and yet is well known to contain a

the atmosphere, and readily parts with its oxygenous or vital part; and it is in consequence of this evaporation and decomposition of the morning dews, that those streams of vital*air are poured into the atmosphere, occasioning the invigorating and freshening sensations which are felt early in a summer's morning, or by the sides of rivers, or after thunder storms. In proportion as water is decomposed, it becomes vapid and ill tasted, and unfit for the purposes of life; and at last a putrescent mass, highly charged with inflammable or foul air, discharging unwholesome and pestilential vapours.

When water, in consequence of stagnation, has been partly decomposed, by violent agitation, it greedily absorbs vital air from the surrounding atmosphere, till it has recovered its due proportion.

Stagnant water is warmer, from its concentrating the rays of the sun into distinct focuses. Agitated water, by refracting and breaking the rays of the sun, continues nearly of the same temperature, and is kept cool, in consequence of the evaporation occasioned by the mist or small particles thrown up by agitation. Take a quantity of water, which by a stagnation has become vapid, and ill tasted, and agitate it in the open air a few minutes, by pouring it hastily from one cup to another, and it will recover its briskness and vivacity. It is by this means, that sea-water, and the waters of streams and rivers, preserve their freshness.

In most of the larger ships of the navy, and in merchantmen destined for long voyages, an apparatus is made use of for refreshing water that is become foul: this consists in a series of perforated receptacles, like cullenders, through which the water passes from one to the other in drops, and which in its passage imbibes its proper proportion of oxygene or vital air.]

Dr. Turton on cold and hot baths.

large mixture of salt and bitumen. On the contrary, those waters which are lightest, have the fewest dissolutions floating in them; and may, therefore, be the most useful for all the purposes of life. But, after all, though much has been said upon this subject; and although waters have been weighed with great assiduity, to determine their degree of salubrity; yet neither this, nor their curdling with soap, nor any other philosophical standard whatsoever, will answer the purposes of true information. Experience alone ought to determine the useful or noxious qualities of every spring; and experience assures us, that different kinds of water are adapted to different constitutions. An incontestable proof of this, are the many medicinal springs throughout the world, whose peculiar benefits are known to the natives of their respective countries. These are of various kinds according to the different minerals with which they are impregnated; hot, saline, sulphureous, bituminous, and oily. But the account of these will come most properly under that of the several minerals by which they are produced.

After all, therefore, we must be contented with an impure mixture for our daily beverage: and yet, perhaps, this very mixture may often be more serviceable to our health than that of a purer kind. We know that it is so with regard to vegetable: and why not, also, in general, to man? Be this as it will, if we are desirous of having water in its greatest purity, we are ordered, by the curious in this particular, to distil it from snow, gathered upon the tops of the highest mountains, and to take none but the outer and superficial

part thereof. This we must be satisfied to call pure water; but even this is far short of the pure unmixed philosophical element; which, in reality, is no where to be found.

As water is thus mixed with foreign matter, and often the repository of minute animals, or vegetable seeds, we need not be surprised that, when carried to sea, it is always found to putrefy. But, we must not suppose that it is the element itself, which thus grows putrid, and offensive, but the substances with which it is impregnated. It is true, the utmost precautions are taken to destroy all vegetable and animal substances that may have previously been lodged in it, by boiling: but, notwithstanding this, there are some that will still survive the operation; and others, that find their way during the time of its stowage. Seamen, therefore, assure us, that their water is generally found to putrefy twice at least, and sometimes three times, in a long voyage. In about a month after it has been at sea, when the bung is taken out of the cask, it sends up a noisome and dangerous vapour, which would take fire upon the application of a candle.* The whole body of the water then is found replete with little wormlike insects, that float, with great briskness, through all its parts. These generally live for about a couple of days; and then dying, by depositing their spoils, for a while increase the putrefaction. After a time, the heavier parts of these sinking to the bottom, the lighter float, in a scum, at the top; and this is what the mariners call the

* Phil. Trans. vol. v. part ii. p. 71.

water's purging itself. There are still, however, another race of insects, which are bred, very probably, from the spoils of the former; and produce, after some time, similar appearances: these dying, the water is then thought to change no more. However, it very often happens, especially in hot climates, that nothing can drive these nauseous insects from the ship's store of water. They often increase to a very disagreeable and frightful size, so as to deter the mariner, though parching with thirst, from tasting that cup which they have contaminated.

This water, as thus described, therefore, is a very different fluid from that simple elementary substance upon which philosophical theories have been founded; and concerning the nature of which there have been so many disputes. Elementary water is no way compounded; but is without taste, smell, or colour; and incapable of being discerned by any of the senses, except the touch. This is the famous dissolvent of the chemists, into which, as they have boasted, they can reduce all bodies; and which makes up all other substances, only by putting on a different disguise. In some forms, it is fluid, transparent, and evasive of the touch; in others, hard, firm, and elastic. In some it is stiffened by cold; in others dissolved by fire. According to them, it only assumes external shapes from accidental causes; but the mountain is as much a body of water as the cake of ice that melts on its brow; and even the philosopher himself is composed of the same materials with the cloud or meteor which he contemplates.

Speculation seldom rests when it begins. Others,

disallowing the universality of this substance, will not allow that in a state of nature there is any such thing as water at all. What assumes the appearance, say they, is nothing more than melted ice. Ice is the real element of Nature's making; and when found in a state of fluidity, it is then in a state of violence. All substances are naturally hard; but some more readily melt with heat than others. It requires a great heat to melt iron; a smaller heat will melt copper: silver, gold, tin, and lead, melt with smaller still: ice, which is a body like the rest, melts with a very moderate warmth; and quicksilver melts with the smallest warmth of all. Water, therefore, is but ice kept in continual fusion; and still returning to its former state, when the heat is taken away. Between these opposite opinions, the controversy has been carried on with great ardour; much has been written on both sides; and yet, when we come to examine the debate, it will probably terminate in this question, whether cold or heat first began their operations upon water? This is a fact of very little importance, if known; and what is more, it is a fact we can never know.

Indeed, if we examine into the operations of cold and heat upon water, we shall find that they produce somewhat similar effects. Water dilates in its bulk, by heat, to a very considerable degree; and what is more extraordinary, it is likewise dilated by cold in the same manner.

If water be placed over a fire, it grows gradually larger in bulk, as it becomes hot, until it begins to boil; after which no art can either increase its bulk, or its heat. By increasing the

fire, indeed, it may be more quickly evaporated away; but its heat and its bulk still continue the same. By the expanding of this fluid by heat, philosophers have found a way to determine the warmth or the coldness of other bodies: for if put into a glass tube, by its swelling and rising, it shows the quantity of heat in the body to which it is applied; and by its contracting, and sinking, it shows the absence of the same. Instead of using water in this instrument, which is called a thermometer, they now make use of spirit of wine, which is not apt to freeze, and which is endued even with a greater expansion, by heat, than water. The instrument consists of nothing more than a hollow ball of glass, with a long tube growing out of it. This being partly filled with spirits of wine, tinctured red, so as to be seen when it rises, the ball is plunged into boiling water, which making the spirit within expand and rise in the tube, the water marks the greatest height to which it ascends; at this point the tube is to be broken off, and then hermetically sealed, by melting the glass with a blow-pipe: a scale being placed by the side, completes the thermometer. Now as the fluid expands or condenses with heat or cold, it will rise and fall in the tube in proportion; and the degree or quantity of ascent or descent will be seen in the scale.

No fire, as was said, can make water hotter, after it begins to boil. We can therefore at any time be sure of an equable certain heat; which is that of boiling water, which is invariably the same. The certainty of such a heat is not less useful than the instrument that measures it. It affords a standard,

fixed degree of heat over the whole world; boiling water being as hot in Greenland as upon the coasts of Guinea. One fire is more intense than another: of heat there are various degrees; but boiling water is a heat every where the same, and easily procurable.

As heat thus expands water, so cold, when it is violent enough to freeze the same, produces exactly the same effect, and expands it likewise. Thus water is acted upon in the same manner by two opposite qualities; being dilated by both. As a proof that it is dilated by cold, we have only to observe the ice floating on the surface of a pond, which it would not do were it not dilated, and grown more bulky, by freezing, than the water which remains unfroze. Mr. Boyle, however, put the matter past a doubt, by a variety of experiments.* Having poured a proper quantity of water into a strong earthen vessel, he exposed it, uncovered, to the open air, in frosty nights: and observed, that continually the ice reached higher than the water before it was frozen. He filled also a tube with water, and stopped both ends with wax: the water, when frozen, was found to push out the stopples from both ends; and a rod of ice appeared at each end of the tube, which showed how much it was swollen by the cold within.

From hence, therefore, we may be very certain of the cold's dilating of the water; and experience also shows, that the force of this expansion has been found as great as any which heat has been found to produce. The touch-hole of a strong

* Boyle, vol. i. p. 610.

gun-barrel being stopped, and a plug of iron forcibly driven into the muzzle, after the barrel had been filled with water, it was placed in a mixture of ice and salt: the plug, though soldered to the barrel, at first gave way, but being fixed in more firmly, within a quarter of an hour the gun-barrel burst with a loud noise, and blew up the cover of the box wherein it lay. Such is its force in an ordinary experiment. But it has been known to burst cannons, filled with water, and then left to freeze; for the cold congealing the water, and the ice swelling, it became irresistible. The bursting of rocks, by frost, which is frequent in the Northern climates, and is sometimes seen in our own, is an equal proof of the expansion of congealed water; for having, by some means, insinuated itself into the body of the rock, it has remained there till the cold was sufficient to affect it by congelation. But when once frozen, no obstacle is able to confine it from dilating; and, if it cannot otherwise find room, the rock must burst asunder.

This alteration in the bulk of water might have served as a proof that it was capable of being compressed into a narrower space than it occupied before; but, till of late, water was held to be incompressible. The general opinion was, that no art whatsoever could squeeze it into a narrower compass; that no power on earth, for instance, could force a pint of water into a vessel that held a hair's breadth less than a pint. And this, said they, appears from the famous Florentine experiment; where the water, rather than suffer compressure, was seen to ooze through the

pores of the solid metal; and, at length, making a cleft in the side, spun out, with great vehemence. But later trials have proved that water is very compressible, and partakes of that elasticity which every other body possesses in some degree. Indeed, had not mankind been dazzled by the brilliancy of one inconclusive experiment, there were numerous reasons to convince them of its having the same properties with other substances. Ice, which is water in another state, is very elastic. A stone flung slantingly along the surface of a pond, bounds from the water several times; which shows it to be elastic also. But the trials of Mr. Canton have put this past all doubt; which being somewhat similar to those of the great Boyle, who pressed it with weights properly applied, carry sufficient conviction.

What has been hitherto related, is chiefly applicable to the element of water alone; but its fluidity is a property that it possesses in common with several other substances, in other respects greatly differing from it. That quality which gives rise to the definition of a fluid, namely, that its parts are in a continual intestine motion, seems extremely applicable to water. What the shapes of those parts are, it would be vain to attempt to discover. Every trial only shows the futility of the attempt; all we find is, that they are extremely minute; and that they roll over each other with the greatest ease. Some, indeed, from this property alone, have not hesitated to pronounce them globular; and we have in all our hydrostatical books, pictures of these little globes in a state of sliding and rolling over each other. But

all this is merely the work of imagination; we know that substances of any kind, reduced very small, assume a fluid appearance, somewhat resembling that of water. Mr. Boyle, after finely powdering and sifting a little dry powder of plaister of Paris, put it in a vessel over the fire, where it soon began to boil like water, exhibiting all the motions and appearances of a boiling liquor. Although but a powder, the parts of which we know are very different from each other, and just as accident has formed them, yet it heaved in great waves, like water. Upon agitation, a heavy body will sink to the bottom, and a light one emerge to the top. There is no reason to suppose the figure of the parts of water round, since we see their fluidity very well imitated by a composition, the parts of which are of various forms and sizes. The shape of the parts of water, therefore, we must be content to continue ignorant of. All we know is, that earth, air, and fire, conduce to separate the parts from each other.

Earthy substances divide the parts from each other, and keep them asunder. This division may be so great, that the water will entirely lose its fluidity thereby. Mud, potter's clay, and dried bricks, are so many different combinations of earth and water; each substance in which the parts of water are most separated from each other, appearing to be the most dry. In some substances, indeed, where the parts of water are greatly divided, as in porcelain, for instance, it is no easy matter to recover and bring them together again; but they continue in a manner

fixed and united to the manufactured clay. This circumstance led Dr. Cheney into a very peculiar strain of thinking. He suspected that the quantity of water, on the surface of the earth, was daily decreasing. For, says he, some parts of it are continually joined to vegetable, animal, and mineral substances, which no art can again recover. United with these, the water loses its fluidity; for if, continues he, we separate a few particles of any fluid, and fasten them to a solid body, or keep them asunder, they will be a fluid no longer. To produce fluidity, a considerable number of such particles are required; but here they are close, and destitute of their natural properties. Thus, according to him, the world is growing every day harder and harder, and the earth firmer and firmer; and there may come a time when every object around us may be stiffened in universal frigidity! However, we have causes enough of anxiety in this world already, not to add this preposterous concern to the number.

That air also contributes to divide the parts of water, we can have no manner of doubt; some have even disputed whether water be not capable of being turned into air. Though this cannot be allowed, it must be granted, that it may be turned into a substance which greatly resembles air (as we have seen in the experiment of the æolipile) with all its properties; except that, by cold, this new-made air may be condensed again into water.

But of all the substances which tend to divide the parts of water, fire is the most powerful. Water, when heated into steam, acquires such force, and the parts of it tend to fly off from each

other with such violence, that no earthly substance we know of is strong enough to confine them. A single drop of water, converted into steam, has been found capable of raising a weight of twenty tons; and would have raised twenty thousand, were the vessel confining it sufficiently strong, and the fire below increased in proportion.

From this easy yielding of its parts to external pressure, arises the art of determining the specific gravity of bodies by plunging them in water; with many other useful discoveries in that part of natural philosophy, called hydrostatics. The laws of this science, which Archimedes began, and Pascal, with some other of the moderns, have improved, rather belongs to experimental than to natural history. However, I will take leave to mention some of the most striking paradoxes in this branch of science, which are as well confirmed by experiment, as rendered universal by theory. It would indeed be unpardonable, while discoursing on the properties of water, to omit giving some account of the manner in which it sustains such immense bulks as we see floating upon its soft and yielding surface: how some bodies, that are known to sink at one time, swim with ease, if their surface be enlarged: how the heaviest body, even gold itself, may be made to swim upon water; and how the lightest, such as cork, shall remain sunk at the bottom: how the pouring in of a single quart of water, will burst a hogshead hooped with iron: and how it ascends, in pipes, from the valley, to travel over the mountain: these are circumstances that are at first surprising; but, upon a slight consideration, lose their wonder.

* In order to conceive the manner in which all these wonders are effected, we must begin by observing that water is possessed of an invariable property, which has not hitherto been mentioned; that of always keeping its surface level and even. Winds, indeed, may raise it into waves; or art spurt it up in fountains; but ever, when left to itself, it sinks into a smooth even surface, of which no one part is higher than another. If I should pour water, for instance, into the arm of a pipe of the shape of the letter U, the fluid would rise in the other arm just to the same height; because, otherwise, it would not find its level, which it invariably maintains. A pipe bending from one hill down into the valley, and rising by another, may be considered as a tube of this kind, in which the water, sinking in one arm, rises to maintain its level in the other. Upon this principle all water-pipes depend; which can never raise the water higher than the fountain from which they proceed.

Again, let us suppose for a moment, that the arms of the pipe already mentioned, may be made long or short at pleasure; and let us still further suppose, that there is some obstacle at the bottom of it, which prevents the water poured into one arm, from rising in the other. Now it is evident, that this obstacle at the bottom will sustain a pressure from the water in one arm, equal to what would make it rise in the other; and this pressure will be great, in proportion as the arm filled with

* In the above sketch, the manner of demonstrating used by Monsieur D'Alembert is made use of as the most obvious, and the most satisfactory. Vide Essai sur, &c.

water is tall. We may, therefore, generally conclude, that the bottom of every vessel is pressed by a force, in proportion to the height of the water in that vessel. For instance, if the vessel filled with water be forty feet high, the bottom of that vessel will sustain such a pressure as would raise the same water forty feet high, which is very great. Hence we see how extremely apt our pipes that convey water to the city are to burst; for descending from a hill of more than forty feet high, they are pressed by the water contained in them, with a force equal to what would raise it more than forty feet high; and that this is sometimes able to burst a wooden pipe, we can have no room to doubt of.

Still recurring to our pipe, let us suppose one of its arms ten times as thick as the other; this will produce no effect whatsoever upon the obstacle below, which we supposed hindering its rise in the other arm; because, how thick soever the pipe may be, its contents would only rise to its own level; and it will, therefore, press the obstacle with an equal force. We may, therefore, universally conclude, that the bottom of any vessel is pressed by its water, not as it is broad or narrow, but in proportion as it is high. Thus the water contained in a vessel not thicker than my finger, presses its bottom as forcibly as the water contained in a hogshead of an equal height; and, if we made holes in the bottoms of both, the water would burst out as forceful from the one as the other. Hence we may, with great ease, burst a hogshead with a single quart of water, and it has been often done.

We have only,* for this, to place a hogshead on one end, filled with water; we then bore a hole in its top, into which we plant a narrow tin pipe, of about thirty feet high: by pouring a quart of water in to this, at the top, as it continues to rise higher in the pipe, it will press more forcibly on the bottom and sides of the hogshead below, and at last burst it.

Still returning to our simple instrument of demonstration. If we suppose the obstacle at the bottom of the pipe to be moveable, so as that the force of the water can push it up into the other arm; such a body is quicksilver, for instance; now, it is evident, that the weight of water weighing down upon this quicksilver in one arm, will at last press it up in the other arm; and will continue to press it upwards, until the fluid in both arms be upon a par. So that here we actually see quicksilver, the heaviest substance in the world, except gold and platina, floating upon water, which is but a very light substance.

When we see water thus capable of sustaining quicksilver, we need not be surprised that it is capable of floating much lighter substances, ships, animals, or timber. When any thing floats upon water, we always see that a part of it sinks in the same. A cork, a ship, a buoy, each buries itself a bed on the surface of the water; this bed may be considered as so much water displaced; the water will, therefore, lose so much of its own weight as is equal to the weight of that bed of water which it displaces. If the body be heavier than a similar bulk of water, it will sink; if lighter, it will swim. Universally, therefore, a body plunged in water,

* Nollet's Lectures.

loses as much of its weight as is equal to the weight of a body of water of its own bulk. Some light bodies, therefore, such as cork, lose much of their weight, and therefore swim; other more ponderous bodies sink, because they are heavier than their bulk of water.

Upon this simple theorem entirely depends the art of weighing metals hydrostatically. I have a guinea, for instance, and desire to know whether it be pure gold: I have weighed it in the usual way with another guinea, and find it exactly of the same weight, but still I have some suspicion, from its greater bulk, that it is not pure. In order to determine this, I have nothing more to do than to weigh it in water with that same guinea that I know to be good, and of the same weight; and this will instantly show the difference; for the true ponderous metal will sink, and the false bulky one will be sustained in proportion to the greatness of its surface. Those whose business it is to examine the purity of metals, have a balance made for this purpose, by which they can precisely determine which is most ponderous, or, as it is expressed, which has the greatest specific gravity. Seventy-one pound and a half of quicksilver is found to be equal in bulk to a hundred pound weight of gold. In the same proportion, sixty of lead, fifty-four of silver, forty-seven of copper, forty-five of brass, forty-two of iron, and thirty-nine of tin, are each equal to a hundred pound of the most ponderous of all metals.

This method of precisely determining the purity of gold, by weighing in water, was first discovered by Archimedes, to whom mankind have been in-

debted for many useful discoveries. Hiero, king of Sicily, having sent a certain quantity of gold to be made into a crown, the workman, it seems, kept a part for his own use, and supplied the deficiency with a baser metal. His fraud was suspected by the king, but could not be detected, till he applied to Archimedes, who weighed the crown in water; and, by this method, informed the king of the quantity of gold which was taken away.

It has been said, that all fluids endeavour to preserve their level; and, likewise, that a body pressing on the surface, tended to destroy that level. Hence it will easily be inferred, that the deeper any body sinks, the greater will be the resistance of the depressed fluid beneath. It will be asked, therefore, as the resistance increases in proportion as the body descends, how comes the body, after it is got a certain way, to sink at all? The answer is obvious. From the fluid above pressing it down with almost as great a force as the fluid beneath presses it up. Take away, by any art, the pressure of the fluid from above, and let only the reristance of the fluid from below be suffered to act, and after the body is got down very deep, the resistance will be insuperable. To give an instance: a small hole opens in the bottom of a ship at sea, forty feet we will suppose below the surface of the water; through this the water bursts up with great violence; I attempt to stop it with my hand; but it pushes the hand violently away. Here the hand is, in fact, a body attempting to sink upon water, at a depth of forty feet, with the pressure from above taken away. The water, therefore, will overcome my strength; and will continue to burst

in till it has got to its level: if I should then dive into the hold, and clap my hand upon the opening as before, I should perceive no force acting against my hand at all, for the water above presses the hand as much down against the hole, as the water without presses it upward. For this reason, also, when we dive to the bottom of the water, we sustain a very great pressure from above, it is true, but it is counteracted by the pressure from below; and the whole acting uniformly on the surface of the body, wraps us close round without injury.

As I have deviated thus far, I will just mention one or two properties more, which water, and all such like fluids, is found to possess. And first, their ascending in vessels which are emptied of air, as in our common pumps for instance. The air, however, being the agent in this case, we must previously examine its properties, before we undertake the explanation. The other property to be mentioned is, that of their ascending in small capillary tubes. This is one of the most extraordinary and inscrutable appearances in nature. Glass tubes may be drawn, by means of a lamp, as fine as a hair; still preserving their hollow within. If one of these be planted in a vessel of water, or spirit of wine, the liquor will immediately be seen to ascend; and it will rise higher, in proportion as the tube is smaller; a foot, two feet, and more. How does this come to pass? Is the air the cause? No: the liquor rises, although the air be taken away. Is attraction the cause? No: for quicksilver does not ascend, which it otherwise would. Many have been the theories of experimental philosophers to explain this property. Such as are

fond of travelling in the regions of conjecture, may consult Hawksbee, Morgan, Jurin, or Watson, who have examined the subject with great minuteness. Hitherto, however, nothing but doubts instead of knowledge have been the result of their inquiries. It will not, therefore, become us to enter into the minuteness of the inquiry, when we have so many greater wonders to call our attention away.*

CHAP. XIV.

Of the Origin of Rivers.

THE sun ariseth, and the sun goeth down, and pants for the place from whence he arose. All things are filled with labour, and man cannot utter it. All rivers run into the sea, yet the sea is not full. Unto the place whence the rivers come, thither they return again. The eye is not satisfied

[* This phenomenon which has so long embarrassed philosophers, is easily soluble upon the principle, that the attraction between the particles of glass and water is greater than the attraction between the particles of water themselves: for, if a glass tube be held parallel to the horizon, and a drop of water be applied to the under side of the tube, it will adhere to it: nor will it fall from the glass, till its bulk and gravity are so far increased as to overbalance the attraction of the glass. Hence it is easy to conceive, how sensibly such a power must act on the surface of a fluid, not viscid as water, contained within the cavity of a small glass tube; as also that the quantity of the fluid raised, will be as the surface of the bore which it fills, that is, as the diameter of the tube.]

with seeing, nor the ear with hearing.* Thus speaks the wisest of the Jews. And, at so early a period was the curiosity of man employed in observing these great circulations of nature. Every eye attempted to explain those appearances; and every philosopher who has long thought upon the subject, seems to give a peculiar solution. The inquiry whence rivers are produced: whence they derive those unceasing stores of water, which continually enrich the world with fertility and verdure: has been variously considered; and divided the opinions of mankind, more than any other topic in natural history.

In this contest, the various champions may be classed under two leaders, Mr. De la Hire, who contends that rivers must be supplied from the sea, strained through the pores of the earth; and Dr. Halley, who has endeavoured to demonstrate, that the clouds alone are sufficient for the supply. Both sides have brought in mathematics to their aid; and have shewn, that long and laborious calculations can at any time be made, to obscure both sides of a question.

De la Hire † begins his proofs, that rain-water, evaporated from the sea, is insufficient for the production of rivers; by shewing, that rain never penetrates the surface of the earth above sixteen inches. Thence he infers, that it is impossible for it, in many cases, to sink so as to be found at such considerable depths below. Rain-water, he grants, is often seen to mix with rivers, and to swell their

* Ecclesiastes, chap. i. ver. 5, 7, 8.

† Hist. de l'Acad. 1713. p. 56.

currents; but a much greater part of it evaporates. In fact, continues he, if we suppose the earth every where covered with water, evaporation alone would be sufficient to carry off two feet nine inches of it in a year: and yet, we very well know, that scarcely nineteen inches of rain-water falls in that time; so that evaporation would carry off a much greater quantity than is ever known to descend. The small quantity of rain-water that falls is therefore but barely sufficient for the purposes of vegetation. Two leaves of a fig-tree have been found, by experiment, to imbibe from the earth, in five hours and a half, two ounces of water. This implies the great quantity of fluid that must be exhausted in the maintenance of one single plant. Add to this, that the waters of the river Rungis will, by calculation, rise to fifty inches; and the whole country from whence they are supplied never receives fifty inches, in the year, by rain. Besides this, there are many salt springs, which are known to proceed immediately from the sea, and are subject to its flux and reflux. In short, wherever we dig beneath the surface of the earth, except in a very few instances, water is to be found; and it is by this subterraneous water, that springs and rivers, nay, a great part of vegetation itself, is supported. It is this subterraneous water, which is raised into steam by the internal heat of the earth, that feeds plants. It is this subterraneous water that distils through its interstices; and there cooling, forms fountains. It is this that, by the addition of rains, is increased into rivers; and pours plenty over the whole earth.

On the other side of the question,* it is asserted,

* Phil. Trans. vol. ii. p. 128.

that the vapours which are exhaled from the sea, and driven by the winds upon land, are more than sufficient to supply not only plants with moisture, but also to furnish a sufficiency of water to the greatest rivers. For this purpose, an estimate has been made of the quantity of water emptied at the mouth of the greatest rivers; and of the quantity also raised from the sea by evaporation; and it has been found, that the latter by far exceeds the former. This calculation was made by Mr. Mariotte. By him it was found, upon receiving such rain as fell in a year, in a proper vessel, fitted for that purpose, that, one year with another, there might fall about twenty inches of water upon the surface of the earth throughout Europe. It was also computed, that the river Seine, from its source to the city of Paris, might cover an extent of ground, that would supply it annually with above seven millions of cubic feet of this water, formed by evaporation. But, upon computing the quantity which passed through the arches of one of its bridges in a year, it was found to amount only to two hundred and eighty millions of cubic feet, which is not above the sixth part of the former number. Hence it appears, that this river may receive a supply brought to it by the evaporated waters of the sea, six times greater than what it gives back to the sea by its current; and, therefore, evaporation is more than sufficient for maintaining the greatest rivers; and supplying the purposes also of vegetation.

In this manner, the sea furnishes sufficient humidity to the air for furnishing the earth with all necessary moisture. One part of its vapours fall upon its own bosom, before they arrive upon land.

Another part is arrested by the sides of mountains; and is compelled, by the rising stream of air, to mount upward towards the summits. Here it is presently precipitated, dripping down by the crannies of the stone. In some places, entering into the caverns of the mountain, it gathers in those receptacles, which being once filled, all the rest overflows; and breaking out by the sides of the hills, forms single springs. Many of these run down by the vallies, or guts between the ridges of the mountain, and form little rivulets or brooks; many of these meeting in one common valley, and gaining the plain ground, being grown less rapid, become a river: and many of these uniting, make such vast bodies of water as the Rhine, the Rhone, and the Danube.

There is still a third part, which falls upon the lower grounds, and furnishes plants with their wonted supply. But the circulation does not rest even here; for it is again exhaled into vapour by the action of the sun; and afterwards returned to that great mass of waters whence it first arose. This, adds Doctor Halley, seems the most reasonable hypothesis; and much more likely to be true than that of those who derive all springs from the filtering of the sea waters through certain imaginary tubes or passages within the earth; since it is well known, that the greatest rivers have their most copious fountains the most remote from the sea.*

This seems the most general opinion; and yet, after all, it is still pressed with great difficulties; and

* Phil. Trans. vol. ii. p. 128.

there is still room to look out for a better theory. The perpetuity of many springs, which always yield the same quantity when the least rain or vapour is afforded, as well as when the greatest, is a strong objection. Derham * mentions a spring at Upminster, which he could never perceive by his eye to be diminished, in the greatest draughts, even when all the ponds in the country, as well as an adjoining brook, have been dry for several months together. In the rainy seasons, also, it was never overflowed; except sometimes, perhaps, for an hour or so, upon the immission of the external rains. He, therefore, justly enough concludes, that had this spring its origin from rain or vapour, there would be found an increase or decrease of its water, corresponding to the causes of its production.

Thus the reader, after having been tossed from one hypothesis to another, must at last be contented to settle in conscious ignorance. All that has been written upon this subject, affords him rather something to say, than something to think; something rather for others than for himself. Varenius, indeed, although he is at a loss for the origin of rivers, is by no means so as to their formation. He is pretty positive that all rivers are artificial. He boldly asserts, that their channels have been originally formed by the industry of man. His reasons are, that when a new spring breaks forth, the water does not make itself a new channel, but spreads over the adjacent land. Thus, says he, men are obliged to direct its course; or, otherwise

* Derham Physico-Theol.

Nature would never have found one. He enumerates many rivers, that are certainly known, from history, to have been dug by men. He alleges, that no salt-water rivers are found, because men did not want salt-water; and as for salt, that was procurable at a less expense than digging a river for it. However, it costs a speculative man but a small expense of thinking to form such an hypothesis. It may, perhaps, engross the reader's patience to detain him longer upon it.

Nevertheless, though philosophy be thus ignorant, as to the production of rivers, yet the laws of their motion, and the nature of their currents, have been very well explained. The Italians have particularly distinguished themselves in this respect, and it is chiefly to them that we are indebted for the improvement.*

All rivers have their source either in mountains, or elevated lakes; and it is in their descent from these, that they acquire that velocity which maintains their future current. At first their course is generally rapid and headlong; but it is retarded in its journey by the continual friction against its banks, by the many obstacles it meets to divert its stream, and by the plains generally becoming more level as it approaches towards the sea.

If this acquired velocity be quite spent, and the plain through which the river passes is entirely level, it will, notwithstanding, still continue to run from the perpendicular pressure of the water, which is always in exact proportion to the depth. This perpendicular pressure is nothing

* S. Guglielmini della Natura de Fiumi, passim.

more than the weight of the upper waters pressing the lower out of their places, and consequently driving them forward, as they cannot recede against the stream. As this pressure is greatest in the deepest parts of the river, so we generally find the middle of the stream most rapid; both because it has the greatest motion thus communicated by the pressure, and the fewest obstructions from the banks on either side.

Rivers thus set into motion are almost always found to make their own beds. Where they find the bed elevated, they wear its substance away, and deposit the sediment in the next hollow, so as in time to make the bottom of their channels even. On the other hand, the water is continually gnawing and eating away the banks on each side; and this with more force as the current happens to strike more directly against them. By these means it always has a tendency to render them more strait and parallel to its own course. Thus it continues to rectify its banks, and enlarge its bed; and, consequently, to diminish the force of its stream, till there becomes an equilibrium between the force of the water, and the resistance of its banks, upon which both will remain without any further mutation. And it is happy for man that bounds are thus put to the erosion of the earth by water; and that we find all rivers only dig and widen themselves but to a certain degree.*

In those plains† and large vallies where great rivers flow, the bed of the river is usually lower

* Guglielmini della Natura de Fiumi, passim.

† Buffon. De Fleuves, passim, vol. ii.

than any part of the valley. But it often happens that the surface of the water is higher than many of the grounds that are adjacent to the banks of the stream. If, after inundations, we take a view of some rivers, we shall find their banks appear above water, at a time that all the adjacent valley is overflown. This proceeds from the frequent deposition of mud, and such like substances, upon the banks, by the rivers frequently overflowing; and thus, by degrees, they become elevated above the plain; and the water is often seen higher also.

Rivers, as every body has seen, are always broadest at the mouth; and grow narrower towards their source. But what is less known, and probably more deserving curiosity, is, that they run in a more direct channel as they immediately leave their sources; and that their sinuosities and turnings become more numerous as they proceed. It is a certain sign among the savages of North America, that they are near the sea, when they find the rivers winding, and every now and then changing their direction. And this is even now become an indication to the Europeans themselves, in their journies through those trackless forests. As those sinuosities, therefore, increase as the river approaches the sea, it is not to be wondered at, that they sometimes divide, and thus disembogue by different channels. The Danube disembogues into the Euxine by seven mouths; the Nile by the same number; and the Wolga, by seventy.

The currents* of rivers are to be estimated very

* Buffon. De Fleuves, passim, vol. ii.

differently from the manner in which those writers, who have given us mathematical theories on this subject, represent them. They found their calculations upon the surface being a perfect plain, from one bank to the other: but this is not the actual state of Nature; for rivers, in general, rise in the middle; and this convexity is greatest in proportion as the rapidity of the stream is greater. Any person, to be convinced of this, need only lay his eye as nearly as he can on a level with the stream, and looking across to the opposite bank, he will perceive the river in the midst to be elevated considerably above what it is at the edges. This rising in some rivers, is often found to be three feet high; and is ever increased, in proportion to the rapidity of the stream. In this case, the water in the midst of a current loses a part of its weight, from the velocity of its motion; while that at the sides, for the contrary reason, sinks lower. It sometimes, however, happens, that this appearance is reversed; for when tides are found to flow up with violence against the natural current of the water, the greatest rapidity is then found at the sides of the river, as the water there least resists the influx from the sea. On those occasions, therefore, the river presents a concave rather than a convex surface: and, as in the former case, the middle waters rose in a ridge; in this case, they sink in a furrow.

The stream of all rivers is more rapid in proportion as its channel is diminished. For instance, it will be much swifter where it is ten yards broad, than where it is twenty; for the force behind still pushing the water forward, when it comes to the

narrow part, it must make up by velocity what it wants in room.

It often happens that the stream of a river is opposed by one of its jutting banks, by an island in the midst, the arches of a bridge, or some such obstacle. This produces, not unfrequently, a back current; and the water having passed the arch with great velocity, pushes the water on each side of its direct current. This produces a side current, tending to the bank; and not unfrequently a whirlpool; in which a large body of waters are circulated in a kind of cavity, sinking down in the middle. The central point of the whirlpool is always lowest, because it has the least motion: the other parts are supported, in some measure, by the violence of theirs; and, consequently, rise higher as their motion is greater; so, that towards the extremity of the whirlpool must be higher than towards the centre.

If the stream of a river be stopped at the surface, and yet be free below; for instance, if it be laid over by a bridge of boats, there will then be a double current; the water at the surface will flow back, while that at the bottom will proceed with increased velocity. It often happens that the current at the bottom is swifter than at the top, when, upon violent land-floods, the weight of waters towards the source presses the waters at the bottom, before it has had time to communicate its motion to the surface. However, in all other cases, the surface of the stream is swifter than the bottom, as it is not retarded by rubbing over the bed of the river.

It might be supposed that bridges, dams, and

other obstacles in the curent of a river, would retard its velocity. But the difference they make is very inconsiderable. The water, by these stoppages, gets an elevation above the object; which, when it has surmounted, it gives a velocity that recompenses the former delay. Islands and turnings also retard the course of the stream but very inconsiderably; any cause which diminishes the quantity of the water, most sensibly diminishes the force and the velocity of the stream.

An increase* of water in the bed of the river, always increases its rapidity; except in cases of inundation. The instant the river has overflowed its banks, the velocity of its current is always turned that way, and the inundation is perceived to continue for some days; which it would not otherwise do, if, as soon as the cause was discontinued, it acquired its former rapidity.

A violent storm, that sets directly up against the course of the stream, will always retard, and sometimes entirely stop its course. I have seen an instance of this, when the bed of a large river was left entirely dry for some hours, and fish were caught among the stones at the bottom.

Inundations are generally greater towards the source of rivers, than farther down; because the current is generally swifter below than above; and that for the reasons already assigned.

A little river† may be received into a large one, without augmenting either its width or depth. This, which at first view seems a paradox, is yet

* Buffon, vol. ii. p. 62.

† Guglielmini.

very easily accounted for. The little river, in this case, only goes towards increasing the swiftness of the larger, and putting its dormant waters into motion. In this manner, the Venetian branch of the Po was pushed on by the Ferrarese branch and that of Panaro, without any enlargement of its breadth or depth from these accessions.

A river tending to enter another, either perpendicularly, or in an opposite direction, will be diverted, by degrees, from that direction; and be obliged to make itself a more favourable entrance downward, and more conspiring with the stream of the former.

The union of two rivers into one, makes it flow the swifter; since the same quantity of water, instead of rubbing against four shores, now only rubs against two. And, besides, the current being deeper, becomes, of consequence, more fitted for motion.

With respect to the places whence rivers proceed, it may be taken for a general rule, that the largest * and highest mountains supply the greatest and most extensive rivers. It may also be remarked, in whatever direction the ridge of the mountain runs, the river takes an opposite course. If the mountain, for instance, stretches from north to south, the river runs from east to west; and so contrariwise. These are some of the most generally received opinions with regard to the course of rivers; however, they are liable to many exceptions; and nothing but an actual knowledge of each particular river can furnish us with an exact theory of its current.

* Doctor Halley.

The largest rivers of Europe are, first, the Wolga, which is about six hundred and fifty leagues in length, extending from Reschow to Astrachan. It is remarkable of this river, that it abounds with water during the summer months of May and June; but all the rest of the year is so shallow, as scarcely to cover its bottom, or allow a passage for loaded vessels that trade up its stream. It was up this river that the English attempted to trade into Persia, in which they were so unhappily disappointed, in the year 1741. The next in order is the Danube. The course of this is about four hundred and fifty leagues, from the mountains of Switzerland to the Black Sea. It is so deep between Buda and Belgrade, that the Turks and Christians have fleets of men of war upon it, which frequently engaged during the last war between the Ottomans and the Austrians: however, it is unnavigable further down, by reason of its cataracts, which prevent its commerce into the Black Sea. The Don, or Tanais, which is four hundred leagues from the source of that branch of it called the Softna, to its mouth in the Euxine Sea. In one part of its course it approaches near the Wolga; and Peter the Great had actually begun a canal, by which he intended joining those two rivers; but this he did not live to finish. The Nieper, or Borysthenes, which rises in the middle of Muscovy, and runs a course of three hundred and fifty leagues, to empty itself into the Black Sea. The Old Cossacks inhabit the banks and islands of this river; and frequently cross the Black Sea, to plunder the maritime places on the coasts of Turkey. The Dwina, which takes its rise in a province of

the same name in Russia, that runs a course of three hundred leagues, and disembogues into the White Sea, a little below Archangel.

The largest rivers of Asia, are the Hohanho, in China, which is eight hundred and fifty leagues in length, computing from its source at Raja Ribron, to its mouth in the Gulph of Changi. The Jenisca of Tartary, about eight hundred leagues in length, from the Lake Selinga to the Icy Sea. This river is, by some, supposed to supply most of that great quantity of drift wood which is seen floating in the seas near the Arctic circle. The Oby, of five hundred leagues, running from the lake of Kila into the Northern Sea. The Amour, in Eastern Tartary, whose course is about five hundred and seventy-five leagues, from its source to its entrance into the sea of Kamtschatka. The Kiam, in China, five hundred and fifty leagues in length. The Ganges, one of the most noted rivers in the world, and about as long as the former. It rises in the mountains which separate India from Tartary; and running through the dominions of the Great Mogul, discharges itself by several mouths into the bay of Bengal. It is not only esteemed by the Indians for the depth and pureness of its stream, but for a supposed sanctity which they believe to be in its waters. It is visited annually by several hundred thousand pilgrims, who pay their devotions to the river as to a god; for savage simplicity is always known to mistake the blessings of the Deity for the Deity himself. They carry their dying friends from distant countries, to expire on its banks; and to be buried in its stream. The water is lowest in April or May; but the rains beginning to fall soon after, the flat

country is overflowed for several miles, till about the end of September; the waters then begin to retire, leaving a prolific sediment behind, that enriches the soil, and, in a few days time, gives a luxuriance to vegetation, beyond what can be conceived by an European. Next to this may be reckoned the still more celebrated river Euphrates. This rises from two sources, northward of the city Erzerum, in Turcomania; and unites about three days journey below the same; whence, after performing a course of five hundred leagues, it falls into the gulph of Persia, fifty miles below the city of Bassora in Arabia. The river Indus is extended, from its source to its discharge into the Arabian Sea, four hundred leagues.

The largest rivers of Africa are the Senegal, which runs a course of not less than eleven hundred leagues, comprehending the Niger, which some have supposed to fall into it. However, later accounts seem to affirm that the Niger is lost in the sands, about three hundred miles up from the western coasts of Africa. Be this as it may, the Senegal is well known to be navigable for more than three hundred leagues up the country; and how much higher it may reach is not yet discovered, as the dreadful fatality of the inland parts of Africa not only deters curiosity, but even avarice, which is a much stronger passion. At the end of last war, of fifty Englishmen that were sent to the factory at Galam, a place taken from the French, and nine hundred miles up the river, only one returned to tell the fate of his companions, who were destroyed by the climate. The celebrated river Nile is said to be nine hundred and seventy leagues,

from its source among the mountains of the Moon, in Upper Æthiopia, to its opening into the Mediterranean Sea. The sources of this river were considered as inscrutable by the ancients; and the causes of its periodical inundation were equally unknown. They have both been ascertained by the missionaries who have travelled into the interior parts of Æthiopia. The Nile takes its rise in the kingdom of Gojam,* from a small aperture on the top of a mountain, which, though not above a foot and a half over, yet was unfathomable. This fountain, when arrived at the foot of the mountain, expands into a river: and, being joined by others, forms a lake thirty leagues long, and as many broad; from this, its channel, in some measure, winds back to the country where it first began; from thence, precipitating by frightful cataracts, it travels through a variety of desert regions, equally formidable, such as Amhara, Olaca, Damot, and Xaoa. Upon its arrival in the kingdom of Upper Egypt, it runs through a rocky channel, which some late travellers have mistaken for its cataracts. In the beginning of its course, it receives many lesser rivers into it; and Pliny was mistaken, in saying that it received none. In the beginning also of its course, it has many windings; but, for above three hundred leagues from the sea, runs in a direct line. Its annual overflowings arise from a very obvious cause, which is almost universal with the great rivers that take their source near the Line. The rainy season, which is periodical in those climates, floods the rivers; and as this always happens in our summer,

* Kircher Mund. Subt. vol. ii. p. 72.

so the Nile is at that time overflown. From these inundations, the inhabitants of Egypt derive happiness and plenty; and, when the river does not arise to its accustomed heights, they prepare for an indifferent harvest. It begins to overflow about the seventeenth of June; it generally continues to augment for forty days, and decreases in about as many more. The time of increase and decrease, however, is much more inconsiderable now than it was among the ancients. Herodotus informs us, that it was a hundred days rising, and as many falling; which shows that the inundation was much greater at that time than at present. M. Buffon* has ascribed the present diminution, as well to the lessening of the mountains of the Moon, by their substance having so long been washed down with the stream, as to the rising of the earth in Egypt, that has for so many ages received this extraneous supply. But we do not find, by the buildings that have remained since the times of the ancients, that the earth is much raised since then. Besides the Nile in Africa, we may reckon the Zara, and the Coanza, from the greatness of whose openings into the sea, and the rapidity of whose streams, we form an estimate of the great distance from whence they come. Their courses, however, are spent in watering deserts and savage countries, whose poverty or fierceness have kept strangers away.†

* Buffon, vol. ii. p. 82.

[† Mr. Bruce, whose accuracy is now no longer questionable, informs us, that the Nile originates, as Kircher has said, in the country of the Agows, and about 600 yards from the village of Geesh, in the province of Sacala. About the middle of a triangular

But of all parts of the world, America, as it exhibits the most lofty mountains, so also it supplies

marsh; and not quite 40 yards from the foot of the mountain on which Geesh stands, is a circular hillock, raised about three feet from the surface of the marsh itself. The diameter of this hillock is not quite 12 feet, and is surrounded by a shallow trench, which collects the water and sends it off to the east. This is firmly built of sods brought from the sides, and kept constantly in repair by the Agows, who worship the river, and perform their religious ceremonies upon it, as upon an altar. This is the first fountain of the Nile: the second is about 10 feet from the former, a little to the west by south, and is only 11 inches in diameter: the third is about 20 feet S. S. W. from the first. From each of these fountains flows a brisk running rill, which, uniting with the water of the first trench, goes off on the east side in a stream, which our author conjectures would fill a pipe about 2 inches in diameter. The longitude of the principal fountain was found to be 36° 55′ 30″ east of Greenwich.

The Nile, thus formed by the union of streams by these three fountains, runs east for about 30 yards, till it is met by the edge of the land descending from Sacala. By this it is turned gradually N. E. and then due N. and in the 2 miles it flows in that direction, it receives many small springs from each side. From this place it turns to the west, and continues for about 4 miles, where there is a small cataract about 6 feet high: after which, it flows gently through the plains of Goutto, and winds in its direction more than any river Mr. Bruce ever saw. Here it is joined by several small rivulets, and becomes a considerable stream, with high and broken banks. In its course it inclines to the N. E. and receives two other small rivers; turning then sharply to the E. it falls down another cataract, about three miles below which it receives the Jemma, not inferior in size to itself: proceeding to the N. it at last crosses the S. part of the lake Tzana or Dembeia, preserving the colour of its stream during its passage, and issuing out at the W. side of it in the territory of Dara: after reaching Alata, there is the third cataract about 40 feet high, and which Mr. Bruce says was the most magnificent sight he ever beheld. Below this tremendous water-fall, the hill takes a S. E. direction, receiving a great number of streams from

the largest rivers. The foremost of these is the great river Amazon, which, from its source in the lake of Lauricocha, to its discharge into the Western Ocean, performs a course of more than twelve hundred leagues.* The breadth and depth of this river are answerable to its vast length; and, where its width is most contracted, its depth is augmented in proportion. So great is the body of its waters, that other rivers, though before the objects of admiration, are lost in its bosom. It proceeds, after their junction, with its usual appearance, without any visible change in its breadth or rapidity; and, if we may so express it, remains great without

both sides, and taking a direction almost due N. approaches to within 62 miles of its source. In this part of the river, crocodiles are met with in great numbers. It now seems to have forced its passage through a gap in some very high mountains which bound the country of the Ganges, and falls down a cataract of 280 feet high; and immediately below this are two others, both of very considerable height, running afterwards close by Senaar, where plenty of gold is washed down the mountains by the torrents in the rainy season. It afterwards makes a sharp turn to the E. passing by many large towns, inhabited by Arabs; of a white complexion: then passing Gerri, and turning to the N.E. it joins the Tacazze: having at length received the great river Atbara, it turns directly N. for about two degrees, when making a very unexpected turn W. by S. for more than two degrees in longitude, it arrives at Korti: from Korti it runs almost S.W. till it passes Dongola; after which it comes to Moscho, a considerable town and place of refreshment to the caravans passing from Egypt to Ethiopia: thence turning to the N.E. it meets with a chain of mountains in about 22° 15′ longitude, where is the seventh cataract, named Fan Adel, about half as high as that of Alata. This course is now continued, till it falls into the Mediterranean, having passed one other cataract much inferior to any of the rest.]

* Ulloa, vol. i. p. 388.

ostentation. In some places it displays its whole magnificence, dividing into several large branches, and encompassing a multitude of islands; and, at length, discharging itself into the ocean, by a channel of a hundred and fifty miles broad. Another river, that may almost rival the former, is the St. Lawrence, in Canada, which rising in the lake Assiniboils, passes from one lake to another, from Cristinaux to Alempigo; from thence to lake Superior; thence to the lake Hurons; to lake Erie; to lake Ontario; and, at last, after a course of nine hundred leagues, pours their collected waters into the Atlantic ocean. The river Mississippi is of more than seven hundred leagues in length, beginning at its source near the lake Assiniboils, and ending at its opening into the Gulph of Mexico. The river Plate runs a length of more than eight hundred leagues from its source in the river Parana, to its mouth.. The river Oroonoko is seven hundred and fifty leagues in length; from its source near Pasto, to its discharge into the Atlantic Ocean.

Such is the amazing length of the greatest rivers; and even in some of these, the most remote sources very probably yet continue unknown. In fact, if we consider the number of rivers which they receive, and the little acquaintance we have with the regions through which they run, it is not to be wondered at that geographers are divided concerning the sources of most of them. As among a number of roots by which nourishment is conveyed to a stately tree, it is difficult to determine precisely that by which the tree is chiefly supplied; so among the many branches of a great river, it is equally

difficult to tell which is the original. Hence it may easily happen, that a similar branch is taken for the capital stream; and its runnings are pursued, and delineated, in prejudice of some other branch that better deserved the name and the description. In this manner,* in Europe, the Danube is known to receive thirty lesser rivers; the Wolga, thirty-two or thirty-three. In Asia, the Hohanno receives thirty-five; the Jenisca above sixty; the Oby as many; the Amour about forty; the Nanquin receives thirty rivers; the Ganges twenty; and the Euphrates about eleven. In Africa, the Senegal receives more than twenty rivers; the Nile receives not one for five hundred leagues upwards, and then only twelve or thirteen. In America, the river Amazon receives above sixty, and those very considerable; the river St. Lawrence about forty, counting those which fall into its lakes; the Mississippi receives forty; and the river Plate above fifty.

I mentioned the inundations of the Ganges and the Nile, but almost every other great river whose source lies within the tropics, have their stated inundations also. The river Pegu has been called, by travellers, the Indian Nile, because of the similar overflowings of its stream: this it does to an extent of thirty leagues on each side; and so fertilizes the soil, that the inhabitants send great quantities of rice into other countries, and have still abundance for their own consumption. The river Senegal has likewise its inundations, which cover the whole flat country of Negroland, beginning and ending much about the same time with those of

* Buffon, vol. ii. p. 74.

the Nile; as, in fact, both rivers rise from the same mountains. But the difference between the effects of the inundations in each river is remarkable: in the one, it distributes health and plenty: in the other, diseases, famine, and death. The inhabitants along the torrid coasts of the Senegal can receive no benefit from any additional manure the river may carry down to their soil, which is by nature more than sufficiently luxuriant; or, even if they could, they have not industry to turn it to any advantage. The banks, therefore, of the rivers, lie uncultivated, overgrown with rank and noxious herbage, and infested with thousands of animals of various malignity. Every new flood only tends to increase the rankness of the soil, and to provide fresh shelter for the creatures that infest it. If the flood continues but a few days longer than usual, the improvident inhabitants, who are driven up in the higher grounds, want provisions, and a famine ensues. When the river begins to return into its channel, the humidity and heat of the air are equally fatal; and the carcases of infinite numbers of animals, swept away by the inundation, putrefying in the sun, produce a stench that is almost insupportable. But even the luxuriance of the vegetation becomes a nuisance. I have been assured, by persons of veracity who have been up the river Senegal, that there are some plants growing along the coast, the smell of which is so powerful, that it is hardly to be endured. It is certain, that all the sailors and soldiers who have been at any of our factories there, ascribe the unwholesomeness of the voyage up the stream, to the vegetable vapour. However this be, the inundations of the

rivers in this wretched part of the globe, contribute scarcely any advantage, if we except the beauty of the prospects which they afford. These, indeed, are finished beyond the utmost reach of art: a spacious glassy river, with its banks here and there fringed to the very surface by the mangrove-tree that grows down into the water, presents itself to view. Lofty forests of various colours, with openings between, carpeted with green plants, and the most gaudy flowers; beasts and animals of various kinds, that stand upon the banks of the river, and, with a sort of wild curiosity, survey the mariners as they pass, contribute to heighten the scene. This is the sketch of an African prospect; which delights the eye, even while it destroys the constitution.

Besides these annually periodical inundations, there are many rivers that overflow at much shorter intervals. Thus most of those in Peru and Chili have scarcely any motion by night; but upon the appearance of the morning sun, they resume their former rapidity: this proceeds from the mountain snows, which, melting with the heat, increase the stream, and continue to drive on the current while the sun continues to dissolve them. Some rivers also flow with an even, steady current, from their source to the sea; others flow with greater rapidity, their stream being poured down in a cataract, or swallowed by the sands, before they reach the sea.

The rivers of those countries that have been least inhabited, are usually more rocky, uneven, and broken into waterfalls or cataracts, than those where the industry of man has been more prevalent. Wherever man comes, nature puts on

a milder appearance: the terrible and the sublime are exchanged for the gentle and the useful; the cataract is sloped away into a placid stream; and the banks become more smooth and even.* It must have required ages to render the Rhone or the Loire navigable; their beds must have been cleaned and directed; their inequalities removed; and, by a long course of industry, nature must have been taught to conspire with the desires of her controller. Every one's experience must have supplied instances of rivers thus being made to flow more evenly, and more beneficially to mankind; but there are some whose currents are so rapid, and falls so precipitate, that no art can obviate; and that must for ever remain as amazing instances of incorrigible nature.

Of this kind are the cataracts of the Rhine; one of which I have seen exhibit a very strange appearance; it was that at Schaffhausen, which was frozen quite across, and the water stood in columns where the cataract had formerly fallen. The Nile, as was said, has its cataracts. The river Vologda, in Russia, has two. The river Zara, in Africa, has one near its source. The river Velino, in Italy, has a cataract of above a hundred and fifty feet perpendicular. Near the city of Gottenburgh,† in Sweden, the river rushes down from a prodigious high precipice into a deep pit, with a terrible noise, and such dreadful force, that those trees designed for the masts of ships, which are floated down the river, are usually turned upside down in their fall, and often

* Buffon, vol. ii. p. 90.

† Phil. Trans. vol. ii. p. 325.

are shattered to pieces, by being dashed against the surface of the water in the pit; this occurs if the masts fall sideways upon the water; but if they fall endways, they dive so far under water that they disappear for a quarter of an hour, or more: the pit into which they are thus plunged has been often sounded with a line of some hundred fathoms long, but no ground has been found hitherto. There is also a cataract at Powerscourt, in Ireland, in which, if I am rightly informed, the water falls three hundred feet perpendicular; which is a greater descent than that of any other cataract in any part of the world. There is a cataract at Albany, in the province of New York, which pours its stream fifty feet perpendicular. But of all the cataracts in the world, that of Niagara, in Canada, if we consider the great body of water that falls, must be allowed to be the greatest, and the most astonishing.

This amazing fall of water is made by the river St. Lawrence, in its passage from the lake Erie into the lake Ontario. We have already said that St. Lawrence was one of the largest rivers in the world; and yet the whole of its waters are here poured down by a fall of a hundred and fifty feet perpendicular. It is not easy to bring the imagination to correspond with the greatness of the scene; a river extremely deep and rapid, and that serves to drain the waters of almost all North America into the Atlantic ocean, is here poured precipitately down a ledge of rocks, that rise like a wall, across the whole bed of its stream. The width of the river, a little above, is near three quarters of a mile broad, and the rocks, where it

grows narrower, are four hundred yards over. Their direction is not straight across, but hollowing inwards like a horse-shoe; so that the cataract, which bends to the shape of the obstacle, rounding inwards, presents a kind of theatre the most tremendous in nature. Just in the middle of this circular wall of waters, a little island, that has braved the fury of the current, presents one of its points, and divides the stream at top into two; but it unites again long before it has got to the bottom. The noise of the fall is heard at several leagues distance; and the fury of the waters at the bottom of their fall is inconceivable. The dashing produces a mist that rises to the very clouds; and that produces a most beautiful rainbow, when the sun shines. It may easily be conceived, that such a cataract quite destroys the navigation of the stream; and yet some Indian canoes, as it is said, have been known to venture down it with safety.

Of those rivers that lose themselves in the sands, or are swallowed up by chasms in the earth, we have various information. What we are told by the ancients, of the river Alpheus, in Arcadia, that sinks into the ground, and rises again near Syracuse, in Sicily, where it takes the name of Arethusa, is rather more known than credited. But we have better information with respect to the river Tigris being lost in this manner under Mount Taurus; of the Guadilquiver in Spain, being buried in the sands; of the river Greatah, in Yorkshire, running underground, and rising again; and even of the great Rhine itself, a part of which is no doubt lost in the sands, a little above Leyden.

But it ought to be observed of this river, that by much the greatest part arrives at the ocean: for, although the ancient channel which fell into the sea a little to the west of that city, be now entirely choked up, yet there are still a number of small canals, that carry a great body of waters to the sea: and besides, it has also two very large openings, the Lech, and the Waal, below Rotterdam, by which it empties itself abundantly.

Be this as it will, nothing is more common in sultry and sandy deserts, than rivers being thus either lost in the sands, or entirely dried up by the sun. And hence we see, that under the Line, the small rivers are but few; for such little streams as are common in Europe, and which with us receive the name of rivers, would quickly evaporate, in those parching and extensive deserts. It is even confidently asserted, that the great river Niger is thus lost before it reaches the ocean; and that its supposed mouths, the Gambia, and the Senegal, are distinct rivers, that come a vast way from the interior parts of the country. It appears that the rivers under the Line are large; but it is otherwise at the Poles,* where they must necessarily be small. In that desolate region, as the mountains are covered with perpetual ice, which melts but little, or not at all, the springs and rivulets are furnished with a very small supply. Here, therefore, man and beast would perish, and die for thirst, if Providence had not ordered, that in the hardest winter, thaws should intervene, which deposit a small quantity of snow-water in pools

* Krantz's History of Greenland, vol. i. p. 41.

under the ice; and from this source the wretched inhabitants drain a scanty beverage.

Thus, whatever quarter of the globe we turn to, we shall find new reasons to be satisfied with that part of it in which we reside. Our rivers furnish all the plenty of the African stream, without its inundation; they have all the coolness of the Polar rivulet, with a more constant supply; they may want the terrible magnificence of huge cataracts, or extensive lakes, but they are more navigable, and more transparent; though less deep and rapid than the rivers of the torrid zone, they are more manageable, and only wait the will of man to take their direction. The rivers of the torrid zone, like the monarchs of the country, rule with despotic tyranny, profuse in their bounties, and ungovernable in their rage. The rivers of Europe, like their kings, are the friends, and not the oppressors of the people; bounded by known limits, abridged in the power of doing ill, directed by human sagacity, and only at freedom to distribute happiness and plenty.

CHAP. XV.

Of the Ocean in general; and of its Saltness.

IF we look upon a map of the world, we shall find that the ocean occupies considerably more of the globe, than the land is found to do. This immense body of waters is diffused round both the Old and New Continent, to the south; and may surround them also to the north, for what we know.

but the ice in those regions has stopped our inquiries. Although the ocean, properly speaking, is but one extensive sheet of waters, continued over every part of the globe, without interruption, and although no part of it is divided from the rest, yet geographers have distinguished it by different names; as the Atlantic or Western Ocean, the Northern Ocean, the Southern Ocean, the Pacific Ocean, and the Indian Ocean. Others have divided it differently, and given other names; as the Frozen Ocean, the Inferior Ocean, or the American Ocean. But all these being arbitrary distinctions, and not of Nature's making, the naturalist may consider them with indifference.

In this vast receptacle, almost all the rivers of the earth ultimately terminate; nor do such great supplies seem to increase its stores; for it is neither apparently swollen by their tribute, nor diminished by their failure; it still continues the same. Indeed, what is the quantity of water of all the rivers and lakes in the world, compared to that contained in this great receptacle?* If we should offer to make a rude estimate, we shall find that all the rivers in the world, flowing into the bed of the sea, with a continuance of their present stores, would take up at least eight hundred years to fill it to its present height. For, supposing the sea to be eighty-five millions of square miles in extent, and a quarter of a mile upon an average in depth, this, upon calculation, will give above twenty-one millions of cubic miles of water, as the contents of the whole ocean. Now, to esti-

* Buffon, vol. ii. p. 70.

mate the quantity of water which all the rivers supply, take any one of them; the Po, for instance, the quantity of whose discharge into the sea, is known to be one cubic mile of water in twenty-six days. Now it will be found, upon a rude computation, from the quantity of ground the Po, with its influent streams, covers, that all the rivers of the world furnish about two thousand times that quantity of water. In the space of a year, therefore, they will have discharged into the sea about twenty-six thousand cubic miles of water; and not till eight hundred years, will they have discharged as much water as is contained in the sea at present. I have not troubled the reader with the odd numbers, lest he should imagine I was giving precision to a subject that is incapable of it.

Thus great is the assemblage of waters diffused round our habitable globe; and yet, immeasurable as they seem, they are mostly rendered subservient to the necessities and the conveniences of so little a being as man. Nevertheless, if it should be asked whether they be made for him alone, the question is not easily resolved. Some philosophers have perceived so much analogy to man in the formation of the ocean, that they have not hesitated to assert its being made for him alone. The distribution of land and water,* say they, is admirable; the one being laid against the other so skilfully, that there is a just equipoise of the whole globe. Thus the Northern Ocean balances against the Southern; and the New Continent is

* Derham's Physico-Theol.

an exact counterweight to the Old. As to any objection from the ocean's occupying too large a share of the globe, they contend, that there could not have been a smaller surface employed to supply the earth with a due share of evaporation. On the other hand, some take the gloomy side of the question; they either magnify* its apparent defects; or assert, that † what seems defects to us, may be real beauties to some wiser order of beings. They observe, that multitudes of animals are concealed in the ocean, and but a small part of them are known; the rest, therefore, they fail not to say, were certainly made for their own benefit, and not for ours. How far either of these opinions be just, I will not presume to determine; but of this we are certain, that God has endowed us with abilities to turn this great extent of waters to our own advantage. He has made these things, perhaps, for other uses; but he has given us faculties to convert them to our own. This much-agitated question, therefore, seems to terminate here. We shall never know whether the things of this world have been made for our use; but we very well know that we have been made to enjoy them. Let us then boldly affirm, that the earth, and all its wonders, are ours; since we are furnished with powers to force them into our service. Man is the lord of all the sublunary creation; the howling savage, the winding serpent, with all the untameable and rebellious offspring of Nature, are destroyed in the contest, or driven to a distance

* Burnet's Theory, passim.

† Pope's Ethic Epistle, passim.

from his habitations. The extensive and tempestuous ocean, instead of limiting or dividing his power, only serves to assist his industry, and enlarge the sphere of his enjoyments. Its billows, and its monsters, instead of presenting a scene of terror, only call up the courage of this little intrepid being; and the greatest danger that man now fears on the deep, is from his fellow-creatures. Indeed, when I consider the human race as Nature has formed them, there is but very little of the habitable globe that seems made for them. But when I consider them as accumulating the experience of ages, in commanding the earth, there is nothing so great, or so terrible. What a poor contemptible being is the naked savage, standing on the beach of the ocean, and trembling at its tumults! How little capable is he of converting its terrors into benefits; or of saying, behold an element made wholly for my enjoyment! He considers it as an angry deity, and pays it the homage of submission. But it is very different when he has exercised his mental powers; when he has learnt to find his own superiority, and to make it subservient to his commands. It is then that his dignity begins to appear, and that the true Deity is justly praised for having been mindful of man; for having given him the earth for his habitation, and the sea for an inheritance.

This power which man has obtained over the ocean, was at first enjoyed in common; and none pretended to a right in that element where all seemed intruders. The sea, therefore, was open to all till the time of the emperor Justinian. His successor Leo granted such as were in possession of

the shore, the sole right of fishing before their respective territories. The Thracian Bosphorus was the first that was thus appropriated; and from that time it has been the struggle of most of the powers of Europe to obtain an exclusive right in this element. The republic of Venice claims the Adriatic. The Danes are in possession of the Baltic. But the English have a more extensive claim to the empire of all the seas encompassing the kingdoms of England, Scotland, and Ireland; and although these have been long contested, yet they are now considered as their indisputable property. Every one knows that the great power of the nation is exerted on this element; and that the instant England ceases to be superior upon the ocean, its safety begins to be precarious.

It is in some measure owing to our dependance upon the sea, and to our commerce there, that we are so well acquainted with its extent and figure. The bays, gulphs, currents, and shallows of the ocean, are much better known and examined than the provinces and kingdoms of the earth itself. The hopes of acquiring wealth by commerce, has carried man to much greater length than the desire of gaining information could have done. In consequence of this, there is scarcely a strait or a harbour, scarcely a rock or a quicksand, scarcely an inflexion of the shore, or the jutting of a promontory, that has not been minutely described. But as these present very little entertainment to the imagination, or delight to any but those whose pursuits are lucrative, they need not be dwelt upon here. While the merchant and the mariner are solicitous in describing currents and

soundings, the naturalist is employed in observing wonders, though not so beneficial, yet to him of a much more important nature. The saltness of the sea seems to be foremost.

Whence the sea has derived that peculiar bitterish saltness which we find in it, appears, by *Aristotle*, to have exercised the curiosity of naturalists in all ages. He supposed (and mankind were for ages content with the solution) that the sun continually raised dry saline exhalations from the earth, and deposited them upon the sea; and hence, say his followers, the waters of the sea are more salt at top than at bottom. But, unfortunately for this opinion, neither of the facts is true. Sea-salt is not to be raised by the vapours of the sun; and sea-water is not salter at the top than at the bottom. Father Bohours is of opinion that the Creator gave the waters of the ocean their saltness at the beginning; not only to prevent their corruption, but to enable them to bear greater burthens. But their saltness does not prevent their corruption; for stagnant sea water, like fresh, soon grows putrid: and, as for their bearing greater burthens, fresh water answers all the purposes of navigation quite as well. The established opinion, therefore, is that of Boyle,* who supposes, "that the sea's saltness is supplied not only from rocks or masses of salt at the bottom of the sea, but also from the salt which the rains and rivers, and other waters, dissolve in their passage through many parts of the earth, and at length carry with them to the sea." But as there is a difference in the taste of rock-salt

* Boyle, vol. iii. p. 221.

found at land, and that dissolved in the waters of the ocean, this may be produced by the plenty of nitrous and bituminous bodies that, with the salts, are likewise washed into that great receptacle. These substances being thus once carried to the sea, must for ever remain there; for they do not rise by evaporation, so as to be returned back from whence they came. Nothing but the fresh waters of the sea rise in vapours; and all the saltness remains behind. Hence it follows, that every year the sea must become more and more salt; and this speculation Doctor Halley carries so far as to lay down a method of finding out the age of the world by the saltness of its waters. "For if it be observed,"* says he, "what quantity of salt is at present contained in a certain weight of water, taken up from the Caspian Sea, for example, and, after some centuries, what greater quantity of salt is contained in the same weight of water taken from the same place; we may conclude, that in proportion as the saltness has increased in a certain time, so much must it have increased before that time; and we may thus, by the rule of proportion, make an estimate of the whole time wherein the water would acquire the degree of saltness it should be then possessed of." All this may be fine; however, an experiment, begun in this century, which is not to be completed till some centuries hence, is rather a little mortifying to modern curiosity: and, I am induced to think, the inhabitants round the Caspian Sea will not be apt to undertake the inquiry.

This saltness is found to prevail in every part

* Phil. Trans. vol. v. p. 218.

of the ocean; and as much at the surface as at the bottom. It is also found in all those seas that communicate with the ocean; but rather in a less degree.

The great lakes, likewise, that have no outlets nor communication with the ocean, are found to be salt: but some of them in less proportion. On the contrary, all those lakes through which rivers run into the sea, however extensive they be, are, notwithstanding, very fresh: for the rivers do not deposit their salts in the bed of the lake, but carry them, with their currents, into the ocean. Thus the lakes Ontario and Erie, in North America, although for magnitude they may be considered as inland seas, are, nevertheless, fresh-water lakes; and kept so by the river St. Lawrence, which passes through them. But those lakes that have no communication with the sea, nor any rivers going out, although they be less than the former, are, however, always salt. Thus, that which goes by the name of the Dead Sea, though very small, when compared to those already mentioned, is so exceedingly salt, that its waters seem scarcely capable of dissolving any more. The lakes of Mexico, and of Titicacá, in Peru, though of no great extent, are, nevertheless, salt; and both for the same reason.

Those who are willing to turn all things to the best, have not failed to consider this saltness of the sea as a peculiar blessing from Providence, in order to keep so great an element sweet and wholesome. What foundation there may be in the remark, I will not pretend to determine; but we shall shortly find a much better cause for its being kept sweet, namely, its motion.

On the other hand, there have been many who have considered the subject in a different light, and have tried every endeavour to make salt-water fresh, so as to supply the wants of mariners in long voyages, or when exhausted of their ordinary stores. At first it was supposed simple distillation would do; but it was soon found that the bitter part of the water still kept mixed. It was then tried by uniting salt of tartar with sea-water, and distilling both; but here the expense was greater than the advantage. Calcined bones were next thought of; but a hogshead of calcined bones, carried to sea, would take up as much room as a hogshead of water, and was more hard to be obtained. In this state, therefore, have the attempts to sweeten sea-water rested; the chymist satisfied with the reality of his invention; and the mariner convinced of its being useless. I cannot, therefore, avoid mentioning a kind of succedaneum which has been lately conceived to answer the purposes of fresh-water, when mariners are quite exhausted. It is well known, the persons who go into a warm bath, come out several ounces heavier than they went in; their bodies having imbibed a correspondent quantity of water. This more particularly happens, if they have been previously debarred from drinking, or go in with a violent thirst; which they quickly find quenched, and their spirits restored. It was supposed, that in case of a total failure of fresh-water at sea, a warm bath might be made of sea-water, for the use of mariners; and that their pores would thus imbibe the fluid, without any of its salts, which would be seen to crystallize on the surface of their bodies. In this manner, it is supposed,

a sufficient quantity of moisture may be procured to sustain life, till time or accident furnish a more copious supply.

But, however this be, the saltness of the sea can by no means be considered as a principal cause in preserving its waters from putrefaction. The ocean has its currents, like rivers, which circulate its contents round the globe; and these may be said to be the great agents that keep it sweet and wholesome. Its saltness alone would, by no means, answer this purpose: and some have even imagined that the various substances with which it is mixed, rather tend to promote putrescence than impede it. Sir Robert Hawkins, one of our most enlightened navigators, gives the following account of a calm, in which the sea continuing for some time without motion, began to assume a very formidable appearance. "Were it not," says he, "for the moving of the sea, by the force of winds, tides, and currents, it would corrupt all the world. The experiment of this I saw in the year 1590, lying with a fleet about the islands of Azores, almost six months; the greatest part of which time we were becalmed. Upon which all the sea became so replenished with several sorts of jellies, and forms of serpents, adders, and snakes, as seemed wonderful: some green, some black, some yellow, some white, some of divers colours, and many of them had life; and some there were a yard and a half, and two yards long; which had I not seen, I could hardly have believed. And hereof are witnesses all the company of the ships which were then present: so that hardly a man could draw a bucket of water clear of some corruption. In which voyage, towards the end thereof,

many of every ship fell sick, and began to die apace. But the speedy passage into our country was a remedy to the crazed, and a preservative for those that were not touched."

This shows, abundantly, how little the sea's saltness was capable of preserving it from putrefaction: but, to put the matter beyond all doubt, Mr. Boyle kept a quantity of sea-water, taken up in the English Channel, for some time barrelled up; and, in the space of a few weeks, it began to acquire a fetid smell:* he was also assured, by one of his acquaintance, who was becalmed for twelve or fourteen days in the Indian sea, that the water, for want of motion, began to stink; and that had it continued much longer, the stench would probably have poisoned him. It is the motion, therefore, and not the saltness of the sea that preserves it in its present state of salubrity; and this, very probably, by dashing and breaking in pieces the rudiments, if I may so call them, of the various animals that would otherwise breed there, and putrefy.

There are some advantages, however, which are derived from the saltness of the sea. Its waters being evaporated, furnish that salt which is used for domestic purposes; and, although in some places it is made from springs, and, in others, dug out of mines, yet the greatest quantity is made only from the sea. That which is called bay-salt, (from its coming to us by the Bay of Biscay) is a stronger kind, made by evaporation in the sun: that called common salt, is evaporated in pans over the fire, and is of a much inferior quality to the former.

* Boyle, vol. iii. p. 222.

Another benefit arising from the quantity of salt dissolved in the sea, is, that it thus becomes heavier, and, consequently, more buoyant. Mr. Boyle, who examined the difference between sea-water and fresh, found that the former appeared to be about a forty-fifth part heavier than the latter. Those, also, who have had opportunities of bathing in the sea, pretend to have experienced a much greater ease in swimming there, than in fresh-water. However, as we see they have only a forty-fifth part more of their weight sustained by it, I am apt to doubt whether so minute a difference can be practically perceivable. Be this as it may, as sea-water alters in its weight from fresh, so it is found also to differ from itself in different parts of the ocean. In general, it is perceived to be heavier, and consequently salter, the nearer we approach the Line.*

But there is an advantage arising from the saltness of the waters of the sea, much greater than what has been yet mentioned; which is, that their congelation is thus retarded. Some, indeed, have gone so far as to say, that † sea-water never freezes: 'but this is an assertion contradicted by experience. However, it is certain that it requires a much greater degree of cold to freeze it than fresh-water; so that, while rivers and springs are seen converted into one solid body of ice, the sea is always fit for navigation, and no way affected by the coldness of the severest winter. It is, therefore, one of the greatest blessings we derive from this element, that when at land all the stores of Nature

* Phil. Trans. vol. ii. p. 297. † Macrobius.

are locked up from us, we find the sea ever open to our necessities, and patient of the hand of industry.

But it must not be supposed, because in our temperate climate we never see the sea frozen, that it is in the same manner open in every part of it. A very little acquaintance with the accounts of mariners, must have informed us, that at the polar regions it is embarrassed with mountains, and moving sheets of ice, that often render it impassable. These tremendous floats are of different magnitudes; sometimes rising more than a thousand feet above the surface of the water;* sometimes diffused into plains of above two hundred leagues in length; and, in many parts, sixty or eighty broad. They are usually divided by fissures; one piece following another so close, that a person may step from one to the other. Sometimes mountains are seen rising amidst these plains, and presenting the appearance of a variegated landscape, with hills and valleys, houses, churches, and towers. These are appearances in which all naturalists are agreed; but the great contest is respecting their formation. M. Buffon asserts,† that they are formed from fresh-water alone; which congealing at the mouths of great rivers, accumulate those huge masses that disturb navigation. However, this great naturalist seems not to have been aware that there are two sorts of ice floating in these seas; the flat ice, and the mountain ice: the one formed of sea-water only, the other of fresh.‡

The flat, or driving ice, is entirely composed of

* Krantz's History of Greenland, vol. i. p. 31.

† Buffon, vol. ii. p. 91. ‡ Krantz.

sea-water; which, upon dissolution, is found to be salt; and is readily distinguished from the mountain or fresh-water ice, by its whiteness, and want of transparency. This ice is much more terrible to mariners than that which rises up in lumps: a ship can avoid the one, as it is seen at a distance; but it often gets in among the other, which sometimes closing, crushes it to pieces. This, which manifestly has a different origin from the fresh-water ice, may perhaps have been produced in the Icy Sea, beneath the Pole; or along the coasts of Spitzberg, or Nova Zembla.

The mountain-ice, as was said, is different in every respect, being formed of fresh-water, and appearing hard and transparent; it is generally of a pale green colour, though some pieces are of a beautiful sky blue; many large masses, also, appear grey; and some black. If examined more nearly, they are found to be incorporated with earth, stones, and brush-wood, washed from the shore. On these also are sometimes found, not only earth, but nests with birds eggs, at several hundred miles from land. The generality of these, though almost totally fresh, have, nevertheless, a thick crust of salt-water frozen upon them, probably from the power that ice has sometimes to produce ice. Such mountains as are here described, are most usually seen at spring-time, and after a violent storm, driving out to sea, where they at first terrify the mariner, and are soon after dashed to pieces by the continual washing of the waves; or driven into the warmer regions of the south, there to be melted away. They sometimes, however, strike back upon their native shores, where they seem to take root

at the feet of mountains; and, as Martius tells us, are sometimes higher than the mountains themselves. Those seen by him were blue, full of clefts and cavities made by the rain, and crowned with snow, which alternately thawing and freezing every year, augmented their size. These, composed of materials more solid than that driving at sea, presented a variety of agreeable figures to the eye, that, with a little help from fancy, assumed the appearance of trees in blossom; the inside of churches, with arches, pillars, and windows; and the blue coloured rays, darting from within, presented the resemblance of a glory.

If we inquire into the origin and formation of these, which, as we see, are very different from the former, I think we have a very satisfactory account of them in Krantz's History of Greenland; and I will take leave to give the passage, with a very few alterations. "These mountains of ice," says he, "are not salt, like the sea-water, but sweet; and, therefore, can be formed no where except on the mountains, in rivers, in caverns, and against the hills near the sea-shore. The mountains of Greenland are so high, that the snow which falls upon them, particularly on the north side, is, in one night's time, wholly converted into ice: they also contain clefts and cavities, where the sun seldom or never injects his rays: besides these, are projections, or landing places, on the declivities of the steepest hills, where the rain and snow-water lodge, and quickly congeal. When now the accumulated flakes of snow slide down, or fall with the rain from the eminences above on these prominences; or, when here and there a mountain-spring

comes rolling down to such a lodging place, where the ice has already seated itself, they all freeze, and add their tribute to it. This, by degrees, waxes to a body of ice, that can no more be overpowered by the sun; and which, though it may indeed, at certain seasons, diminish by a thaw, yet, upon the whole, through annual acquisitions, it assumes an annual growth. Such a body of ice is often prominent far over the rocks. It does not melt on the upper surface, but underneath; and often cracks into many larger or smaller clefts, from whence the thawed water trickles out. By this it becomes, at last, so weak, that being overloaded with its own ponderous bulk, it breaks loose and tumbles down the rocks with a terrible crash. Where it happens to overhang a precipice on the shore, it plunges into the deep with a shock like thunder: and with such an agitation of the water, as will overset a boat at some distance, as many a poor Greenlander has fatally experienced." Thus are these amazing ice mountains launched forth to sea, and found floating in the waters round both the Poles. It is these that have hindered mariners from discovering the extensive countries that lie round the South Pole: and that probably block up the passage to China by the North.

I will conclude this chapter with one effect more, produced by the saltness of the sea; which is, the luminous appearance of its waves in the night. All who have been spectators of a sea by night, a little ruffled with winds, seldom fail of observing its fiery brightness. In * some places it shines as far as the

* Boyle, vol. i. p. 294.

eye can reach; at other times, only when the waves boom against the side of the vessel, or the oar dashes into the water. Some seas shine often; others more seldom; some, ever when particular winds blow; and others, within a narrow compass; a long tract of light being seen along the surface, whilst all the rest is hid in total darkness. It is not easy to account for these extraordinary appearances: some have supposed that a number of luminous insects produced the effect, and this is in reality sometimes the case; in general, however, they have every resemblance to that light produced by electricity; and, probably, arise from the agitation and dashing of the saline particles of the fluid against each other. But the manner in which this is done, (for we can produce nothing similar by any experiments hitherto made,) remains for some happier accident to discover. Our progress in the knowledge of Nature is slow; and it is a mortifying consideration, that we are hitherto more indebted for success to chance than industry.*

[* Most of the marine insects, and many fish, emit a phosphorescent light when they are in a certain state of decay; and some of them even while they are alive. Who has not seen a mackarel just before it becomes putrid, shining in the dark like a diamond? The author of this note has frequently seen the sea in this state of illumination. It is called by sailors the sea bream, and is generally observable from sun-set till an hour or two afterwards, and always when the air is calm and the water tolerably quiescent. If at this time, the hand be dipped in the water, the drops will run off like gems. Upon filtering some of it, there has always remained behind a great number of those almost invisible marine worms called, in the System of Nature, Nereis noctiluca. It is, therefore, beyond doubt, that this appearance is caused by these and other minute animals of like properties, and is probably

CHAP. XVI.

Of the Tides, Motion and Currents of the Sea; with their Effects.

IT was said, in the former chapter, that the waters of the sea were kept sweet by their motion, without which they would soon putrefy, and spread universal infection. If we look for final causes, here, indeed, we have a great and an obvious one that presents itself before us. Had the sea been made without motion, and resembling a pool of stagnant water, the nobler races of animated nature would shortly be at an end. Nothing would then be left alive but swarms of ill-formed creatures, with scarcely more than vegetable life; and subsisting by putrefaction. Were this extensive bed of waters entirely quiescent, millions of the smaller reptile kinds would there find a proper retreat to breed and multiply in; they would find there no agitation, no concussion in the parts of the fluid to crush their feeble frames, or to force them from the places where they were bred; there they would multiply in security and ease, enjoy a short life, and putrefying, thus again give nourishment to numberless other, as little worthy of existence as themselves. But the motion of this great element effectually destroys the number of these viler crea-

assisted by the decayed phosphorescent particles of fish and sea-worms, floating near the surface of the sea, and driven up by particular winds.]

tures; its currents and its tides produce continual agitations, the shock of which they are not able to endure; the parts of the fluid rub against each other, destroy all viscidities; and the ocean, if I may so express it, acquires health by exercise.

The most obvious motion of the sea, and the most generally acknowledged, is that of its tides. This element is observed to flow for certain hours, from south towards the north; in which motion or flux, which lasts about six hours, the sea gradually swells; so that entering the mouths of rivers, it drives back the river waters to their heads. After a continual flux of six hours, the sea seems to rest for a quarter of an hour; and then begins to ebb, or retire back again, from north to south, for six hours more; in which time the waters sinking, the rivers resume their natural course. After a seeming pause of a quarter of an hour, the sea again begins to flow as before: and thus it has alternately risen and fallen, twice a day, since the creation.

This amazing appearance did not fail to excite the curiosity, as it did the wonder of the ancients. After some wild conjectures of the earliest philosophers, it became well known, in the time of Pliny, that the tides were entirely under the influence, in a small degree, of the sun; but in a much greater, of the moon. It was found that there was a flux and reflux of the sea, in the space of twelve hours fifty minutes, which is exactly the time of a lunar day. It was observed, that whenever the moon was in the meridian, or, in other words, as nearly as possible over any part of the sea, that the sea flowed to that part, and made a tide there; on the

contrary, it was found, that when the moon left the meridian, the sea began to flow back again from whence it came; and there might be said to ebb. Thus far the waters of the sea seemed very regularly to attend the motions of the moon. But it appeared, likewise, that when the moon was in the opposite meridian, as far off on the other side of the globe, that there was a tide on this side also; so that the moon produced two tides, one by her greatest approach to us: and another by her greatest distance from us: in other words, the moon, in once going round the earth, produced two tides, always at the same time; one on the part of the globe directly under her; and the other, on the part of the globe directly opposite.

Mankind continued for several ages content with knowing the general cause of these wonders, hopeless of discovering the particular manner of the moon's operation. Kepler was the first who conjectured that attraction was the principal cause; asserting, that the sphere of the moon's operation extended to the earth, and drew up its waters. The precise manner in which this is done, was discovered by Newton.

The moon has been found, like all the rest of the planets, to attract, and to be attracted by the earth. This attraction prevails throughout our whole planetary system. The more matter there is contained in any body, the more it attracts: and its influence decreases in proportion as the distance, when squared, increases. This being premised, let us see what must ensue upon supposing the moon in the meridian of any tract of the sea. The surface of the water immediately under the

moon is nearer the moon than any other part of the globe is; and, therefore, must be more subject to its attraction than the waters any where else. The waters will, therefore, be attracted by the moon, and rise in a heap; whose eminence will be the highest where the attraction is greatest. In order to form this eminence, it is obvious that the surface, as well as the depths, will be agitated; and that wherever the water runs from one part, succeeding waters must run to fill up the space it has left. Thus the waters of the sea, running from all parts, to attend the motion of the moon, produce the flowing of the tide; and it is high tide at that part wherever the moon comes over it, or to its meridian.

But when the moon travels onward, and ceases to point over the place where the waters were just risen, the cause here of their rising ceasing to operate, they will flow back by their natural gravity, into the lower parts from whence they had travelled; and this retiring of the waters will form the ebbing of the sea.

Thus the first part of the demonstration is obvious; since, in general, it requires no great sagacity to conceive that the waters nearest the moon are most attracted, or raised highest by the moon. But the other part of the demonstration, namely, how there come to be high tides at the same time, on the opposite side of the globe, and where the waters are farthest from the moon, is not so easy to conceive. To comprehend this, it must be observed, that the part of the earth and its waters that are farthest from the moon are the parts of all others that are least attracted by

the moon: it must also be observed, that all the waters, when the moon is on the opposite side of the earth, must be attracted by it in the same direction that the earth itself attracts them; that is, if I may so say, quite through the body of the earth, towards the moon itself. This, therefore, being conceived, it is plain that those waters which are farthest from the moon, will have less weight than those of any other part, on the same side of the globe; because the moon's attraction, which conspires with the earth's attraction, is there least. Now, therefore, the waters farthest from the moon, having less weight, and being lightest, will be pressed on all sides, by those that, having more attraction, are heavier: they will be pressed, I say, on all sides; and the heavier waters flowing in, will make them swell and rise in an eminence directly opposite to that on the other side of the globe, caused by the more immediate influence of the moon.

In this manner the moon, in one diurnal revolution, produces two tides; one raised immediately under the sphere of its influence, and the other directly opposite to it. As the moon travels, this vast body of waters rears upward, as if to watch its motions; and pursues the same constant rotation. However, in this great work of raising the tides, the sun has no small share; it produces its own tides constantly every day, just as the moon does, but in much less degree, because the sun is at an immensely greater distance. Thus there are solar tides, and lunar tides. When the forces of these two great luminaries concur, which they always do when they are either in the same,

or in opposite parts of the heavens, they jointly produce a much greater tide, than when they are so situated in the heavens, as each to make peculiar tides of their own. To express the very same thing technically; in the conjunctions and oppositions of the sun and moon, the attraction of the sun conspires with the attraction of the moon; by which means the high spring-tides are formed. But in the quadratures of the sun and moon, the water raised by the one is depressed by the other; and hence the lower neap-tides have their production. In a word, the tides are greatest in the syzigies, and least in the quadratures.

This theory well understood, and the astronomical terms previously known, it may readily be brought to explain the various appearances of the tides, if the earth were covered with a deep sea, and the waters uninfluenced by shoals, currents, straits, or tempests. But in every part of the sea, near the shores, the geographer must come in to correct the calculations of the astronomer. For, by reason of the shallowness of some places, and the narrowness of the straits in others, there arises a great diversity in the effect, not to be accounted for without an exact knowledge of all the circumstances of the place. In the great depths of the ocean, for instance, a very slow and imperceptible motion of the whole body of water will suffice to raise its surface several feet high; but if the same increase of water is to be conveyed through a narrow channel, it must rush through it with the most impetuous rapidity. Thus, in the English Channel, and the German Ocean, the tide is found to flow strongest in those

places that are narrowest; the same quantity of water being, in this case, driven through a smaller passage. It is often seen, therefore, pouring through a strait with great force; and, by its rapidity, considerably raised above the surface of that part of the ocean into which it runs.

This shallowness and narrowness in many parts of the sea, give also rise to a peculiarity in the tides of some parts of the world. For in many places, and in our own seas in particular, the greatest swell of the tide is not while the moon is in its meridian height, and directly over the place, but some time after it has declined from thence. The sea, in this case, being obstructed, pursues the moon with what dispatch it can, but does not arrive with all its waters till long after the moon has ceased to operate. Lastly, from this shallowness of the sea, and from its being obstructed by shoals and straits, we may account for the Mediterranean, the Baltic, and the Black Sea, having no sensible tides. These, though to us they seem very extensive, are not however large enough to be effected by the influence of the moon; and as to their communication with the ocean, through such narrow inlets, it is impossible in a few hours they should receive and return water enough to raise or depress them in any considerable degree.

In general we may observe, that all tides are much higher, and more considerable in the torrid zone, than in the rest of the ocean; the sea in those parts being generally deeper, and less affected by changeable winds, or winding shores.* The greatest

* Buffon, vol. ii. p. 187.

tide we know of, is that at the mouth of the river Indus, where the water rises thirty feet in height. How great, therefore, must have been the amazement of Alexander's soldiers at so strange an appearance! They who always before had been accustomed only to the scarcely perceptible risings of the Mediterranean, or the minute intumescence of the Black Sea, when made at once spectators of a river rising and falling thirty feet in a few hours, must no doubt have felt the most extreme awe, and, as we are told,* 'a mixture of curiosity and apprehension. The tides are also remarkably high on the coast of Malay, in the straits of Sunda, in the Red Sea, at the mouth of the river St. Lawrence, along the coasts of China and Japan, at Panama, and in the gulph of Bengal. The tides of Tonquin, however, are the most remarkable in the world. In this part there is but one tide, and one ebb, in twenty-four hours; whereas, as we have said before, in other places there are two. Besides, there, twice in each month there is no tide at all, when the moon is near the equinoctial, the water being for some time quite stagnant. These, with some other odd appearances attending the same phænomena, were considered by many as inscrutable; but Sir Isaac Newton, with peculiar sagacity, adjudged them to arise from the concurrence of two tides, one from the South Sea, and the other from the Indian Ocean. Of each of these tides there come successively two every day; two at one time greater, and two at another that are less. The time between the ar-

* Quintus Curtius.

rival of the two greater, is considered by him as high tide; the time between the two lesser, as ebb. In short, with this clue, that great mathematician solved every appearance, and so established his theory, as to silence every opposer.*

This fluctuation of the sea from the tides, produces another, and more constant rotation of its waters, from the east to the west, in this respect following the course of the moon. This may be considered as one great and general current of the waters of the sea; and although it be not every where distinguishable, it is nevertheless every where existent, except when opposed by some particular current or eddy, produced by partial and local causes. This tendency of the sea towards the west is plainly perceivable in all the great straits of the ocean; as, for instance, in those of Magellan, where the tide running in from the east, rises twenty feet high, and continues flowing six hours; whereas the ebb continues but two hours, and the current is directed to the west. This proves that the flux is not equal to the reflux; and that from both results a motion of the sea westward, which

[* M. St. Pierre, a celebrated French philosopher, endeavours to account for the tides, by the alternate semi-annual solution of the ice at the poles. The sun being for nearly six months together alternately above and below the horizon at each of the poles, he supposes must act with great force upon the vast masses of ice there accumulated, and occasion those currents of water, which by the motion of the earth are delivered along the coasts in semidiurnal tides: in all lakes, he observes, though some of them are of vast magnitude, the moon has no influence in producing the least appearance of tide; and in proportion as the earth is removed from the poles, the tides diminish and become at length hardly perceptible.]

is more powerful during the time of the flux than the reflux.

But this motion westward has been sensibly observed by navigators, in their passage back from India to Madagascar, and so on to Africa. In the great Pacific Ocean also it is very perceivable: but the places where it is most obvious, are, as was said, in those straits which join one ocean to another. In the straits between the Maldivia islands, in the gulph of Mexico, between Cuba and Jucatan. In the straits of the gulph of Paria, the motion is so violent, that it hath received the appellation of the Dragon's Mouth. Northward in the sea of Canada, in Waigat's straits, in the straits of Java, and, in short, in every strait where the ocean on one part pours into the ocean on the other. In this manner, therefore, is the sea carried with an unceasing circulation round the globe; and, at the same time that its waters are pushed back and forward with the tide, they have thus a progressive current to the west, which though less observable, is not the less real.

Besides these two general motions of the sea, there are others which are particular to many parts of it, and are called currents. These are found to run in all directions, east, west, north, and south; being formed, as was said above, by various causes; the prominence of the shores, the narrowness of the straits, the variations of the wind, and the inequalities at the bottom. These, though no great object to the philosopher, as their causes are generally local and obvious, are nevertheless of the most material consequence to the mariner; and, without a knowledge of which, he

could never succeed. It often has happened, that when a ship has unknowingly got into one of these, every thing seems to go forward with success, the mariners suppose themselves every hour approaching their wished-for port, the wind fills their sails, and the ship's prow seems to divide the water; but, at last, by miserable experience they find, that instead of going forward, they have been all the time receding. The business of currents, therefore, makes a considerable article in navigation; and the direction of their stream, and their rapidity has been carefully set down. This some do by the observation of the surface of the current; or by the driving of the froth along the shore; or by throwing out what is called the log-line, with a buoy made for that purpose; and by the direction and motion of this, they judge of the setting, and the rapidity of the current.

These currents are generally found to be most violent under the equator, where indeed all the motions of the ocean are most perceivable. Along the coasts of Guinea, if a ship happens to overshoot the mouth of any river it is bound to, the current prevents its return; so that it is obliged to steer out to sea, and take a very large compass, in order to correct the former mistake. These set in a contrary direction to the general motion of the sea westward; and that so strongly, that a passage which with the current is made in two days, is with difficulty performed in six weeks against it. However, they do not extend above twenty leagues from the coast: and ships going to the East Indies, take care not to come within

the sphere of their action. At Sumatra, the currents, which are extremely rapid, run from south to north; there are also strong currents between Madagascar and the Cape of Good Hope. On the western coasts of America, the current always runs from the south to the north, where a south wind, continually blowing, most probably occasions this phænomenon. But the currents that are most remarkable, and those continually flowing, into the Mediterranean sea, both from the ocean by the straits of Gibraltar, and at its other extremity, from the Euxine sea by the Archipelago. This is one of the most extraordinary appearances in nature, this large sea receiving not only the numerous rivers that fall into it, such as the Nile, the Rhone, and the Po, but also a very great influx from the Euxine sea on one part, and the Ocean on the other. At the same time, it is seen to return none of those waters it is thus known to receive: outlets running from it there are none; no rivers but such as bring it fresh supplies; no straits but what are constantly pouring their waters into it. It has therefore been the wonder of mankind in every age, how and by what means this vast concourse of waters are disposed of; or how this sea, which is always receiving, and never returning, is no way fuller than before. In order to account for this, some have said, that the water was re-conveyed by subterraneous passages into the Red Sea.* There is a story told of an Arabian caliph, who caught a dolphin in this sea, admiring the beauty of which, he let it go again,

* Kircher Mund. Subt. vol. i.

having previously marked it by a ring of iron. Some time after a dolphin was caught in the Red Sea, and quickly known by the ring to be the same that had been taken in the Mediterranean before. Such, however, as have not been willing to found their opinions upon a story, have attempted to account for the disposal of the waters of the Mediterranean by evaporation. For this purpose they have entered into long calculations upon the extent of its surface, and the quantity of water that would be raised from such a surface in a year. They then compute how much water runs in by its rivers and straits in that time; and find, that the quantity exhausted by evaporation greatly exceeds the quantity supplied by rivers and seas. This solution, no doubt, would be satisfactory, did not the Ocean, and the Euxine, evaporate as well as the Mediterranean: and as these are subject to the same drain, it must follow, that all the seas will in this respect be upon a par; and, therefore, there must be some other cause for this unperceived drain, and continual supply. This seems to be satisfactorily enough accounted for by Dr. Smith, who supposes an under current running through the straits of Gibraltar to carry out as much water into the Ocean, as the upper current continually carries in from it. To confirm this, he observes, that nearer home, between the north and south foreland, the tide is known to run one way at top, and the ebb another way at bottom. This double current he also confirms by an experiment communicated to him by an able seaman, who being with one of the king's frigates in the Baltic, found he went with his boat into the mid-

stream, and was carried violently by the current; upon which a basket was sunk, with a large cannon-ball, to a certain depth of water, which gave a check to the boat's motion; as the basket sunk still lower, the boat was driven by the force of the water below, against the upper current; and the lower the basket was let down, the stronger the under current was found, and the quicker was the boat's motion against the upper stream, which seemed not to be above four fathom deep. Hence we may readily infer, that the same cause may operate at the straits of Gibraltar; and that while the Mediterranean seems replenishing at top, it may be emptying at bottom.

The number of the currents at sea are impossible to be recounted, nor indeed are they always known; new ones are daily produced by a variety of causes, and as quickly disappear. When a regular current is opposed by another in a narrow strait, or where the bottom of the sea is very uneven, a whirlpool is often formed. These were formerly considered as the most formidable obstructions to navigation, and the ancient poets and historians speak of them with terror; they are described as swallowing up ships, and dashing them against the rocks at the bottom: apprehension did not fail to add imaginary terrors to the description, and placed at the centre of the whirlpool a dreadful den, fraught with monsters whose howlings served to add new horrors to the dashings of the deep. Mankind at present, however, view these eddies of the sea with very little apprehension; and some have wondered how the ancients could have so much overcharged their descrip-

tions. But all this is very naturally accounted for. In those times when navigation was in its infancy, and the slightest concussion of the waves generally sent the poor adventurer to the bottom, it is not to be wondered at that he was terrified at the violent agitations in one of these. When his little ship, but ill fitted for opposing the fury of the sea, was got within the vortex, there was then no possibility of ever returning. To add to the fatality, they were always near the shore; and along the shore was the only place where this ill-provided mariner durst venture to sail. These were therefore dreadful impediments to his navigation; for if he attempted to pass between them and the shore, he was sometimes sucked in by the eddy; and if he attempted to avoid them out at sea, he was often sunk by the storm. But in our time, and in our present improved state of navigation, Charybdis, and the Euripus, with all the other irregular currents of the Mediterranean, are no longer formidable. Mr. Addison, not attending to this train of thinking, upon passing through the straits of Sicily, was surprised at the little there was of terror in the present appearance of Scylla and Charybdis; and seems to be of opinion, that their agitations are much diminished since the times of antiquity. In fact, from the reasons above, all the wonders of the Mediterranean Sea are described in much higher colours than they merit, to us who are acquainted with the more magnificent terrors of the Ocean. The Mediterranean is one of the smoothest and most gentle seas in the world; its tides are scarcely perceivable, except in the gulph of Venice, and shipwrecks are

less known there than in any other part of the world.

It is in the Ocean, therefore, that these whirlpools are particularly dangerous, where the tides are violent, and the tempests fierce. To mention only one, that called the Maelstroom, upon the coasts of Norway, which is considered as the most dreadful and voracious in the world. The name it has received from the natives, signifies the navel of the sea, since they suppose that a great share of the water of the sea is sucked up and discharged by its vortex. A minute description of the internal parts is not to be expected, since none who were there ever returned to bring back information. The body of the waters that form this whirlpool, are extended in a circle above thirteen miles in circumference.* In the midst of this stands a rock, against which the tide in its ebb is dashed with inconceivable fury. At this time it instantly swallows up all things that come within the sphere of its violence, trees, timber, and shipping. No skill ı the mariner, nor strength of rowing, can work ; escape: the sailor at the helm finds the ship at tst go in a current opposite to his intentions; his duel's motion, though slow in the beginning, be- ls every moment more rapid; it goes round in for ɑ still narrower and narrower, till at last it is seem against the rocks, and instantly disappears; their it seen again for six hours: till the tide flow- are c is vomited forth with the same violence arc which it was drawn in. The noise of this kiadful vortex still farther contributes to increase

* Kircher Mund. Subt. vol. i. p. 156.

its terror, which, with the dashing of the waters, and the dreadful valley, if it may be so called, caused by their circulation, makes one of the most tremendous objects in nature.

CHAP. XVII.

Of the Changes produced by the Sea upon the Earth.

FROM what has been said, as well of the earth as of the sea, they both appear to be in continual fluctuation. The earth, the common promptuary that supplies subsistence to men, animals, and vegetables, is continually furnishing its stores to their support. But the matter which is thus derived from it, is soon restored and laid down again to be prepared for fresh mutations. The transmigration of souls is no doubt false and whimsical; but nothing can be more certain than the transmigration ‹e bodies: the spoils of the meanest reptile may go ‹e the formation of a prince; and, on the contrary, ‹a the poet has it, the body of Cæsar may be emplo‹hat in stopping a beer-barrel. From this, and the causes, therefore, the earth is in continual c‹easons Its internal fires, the deviation of its rivers, a‹n Sea falling of its mountains, are daily altering ‹n they face; and geography can scarcely recollect th‹ more and the vallies that history once described. ‹iter-

But these changes are nothing to the instab‹ntle of the ocean. It would seem that inquietude wa‹ as natural to it as its fluidity. It is first seen with

a constant and equable motion going towards the west; the tides then interrupt this progression, and for a time drive the waters in a contrary direction; beside these agitations, the currents act their part in a smaller sphere, being generally greatest where the other motions of the sea are least; namely, nearest the shore: the winds also contribute their share in this universal fluctuation: so that scarcely any part of the sea is wholly seen to stagnate.

Nil enim quiescit, undis impellitur unda,
Et spiritus et calor toto se corpore miscent.

As this great element is thus changed, and continually labouring internally, it may be readily supposed that it produces correspondent changes upon its shores, and those parts of the earth subject to its influence. In fact, it is every day making considerable alterations, either by overflowing its shores in one place, or deserting them in others: by covering over whole tracts of country, that were cultivated and peopled, at one time; or by leaving its bed to be appropriated to the purposes of vegetation, and to supply a new theatre for human industry at another.

In this struggle between the earth and the sea for dominion, the greatest number of our shores seem to defy the whole rage of the waves, both by their height, and the rocky materials of which they are composed. The coasts of Italy, for instance,* are bordered with rocks of marble of different kinds, the quarries of which may easily be dis-

* Buffon, vol. ii. p. 199.

tinguished at a distance from sea, and appear like perpendicular columns of the most beautiful kinds of marble, ranged along the shore. In general, the coasts of France, from Brest to Bordeaux, are composed of rocks; as are also those of Spain and England, which defend the land, and only are interrupted here and there to give an egress to rivers, and to grant the conveniencies of bays and harbours to our shipping. It may be in general remarked, that wherever the sea is most violent and furious, there the boldest shores, and of the most compact materials, are found to oppose it. There are many shores several hundred feet perpendicular, against which the sea, when swollen with tides, or storms, rises and beats with inconceivable fury. In * the Orkneys, where the shores are thus formed, it sometimes, when agitated by a storm, rises two hundred feet perpendicular, and dashes up its spray, together with sand, and other substances that compose its bottom, upon land, like showers of rain.

Hence, therefore, we may conceive how the violence of the sea, and the boldness of the shore, may be said to have made each other. Where the sea meets no obstacles, it spreads its waters with a gentle intumescence, till all its power is destroyed, by wanting depth to aid the motion. But when its progress is checked in the midst, by the prominence of rocks, or the abrupt elevation of the land, it dashes with all the force of its depth against the obstacle, and forms, by its repeated violence, that abruptness of the shore which confines its impetuosity. Where the sea is extremely deep, or very

* Buffon, vol. ii. p. 191.

much vexed by tempests, it is no small obstacle that can confine its rage; and for this reason we see the boldest shores projected against the deepest waters; all less impediments having long before been surmounted and washed away. Perhaps of all the shores in the world, there is not one so high as that on the west of St. Kilda, which, upon a late admeasurement,* was found to be six hundred fathom perpendicular above the surface of the sea. Here, also, the sea is deep, turbulent, and stormy; so that it requires great force in the shore to oppose its violence. In many parts of the world, and particularly upon the coasts of the East Indies, the shores, though not high above water, are generally very deep, and consequently the waves roll against the land with great weight and irregularity. This rising of the waves against the shore, is called by mariners the surf of the sea; and in shipwrecks is generally fatal to such as attempt to swim on shore. In this case, no dexterity in the swimmer, no float he can use, neither swimming girdle nor cork jacket will save him; the weight of the superincumbent waves breaks upon him at once, and crushes him with certain ruin. Some few of the natives, however, have the art of swimming and of navigating their little boats near those shores, where an European is sure of instant destruction.

In places where the force of the sea is less violent, or its tides less rapid, the shores are generally seen to descend with a more gradual declivity. Over these, the waters of the tide steal by almost imperceptible degrees, covering them for a large extent,

* Description of St. Kilda.

and leaving them bare on its recess. Upon these shores, as was said, the sea seldom beats with any great violence, as a large wave has not depth sufficient to float it onwards; so that here only are to be seen gentle surges making calmly towards land, and lessening as they approach. As the sea, in the former description, is generally seen to present prospects of tumult and uproar, here it more usually exhibits a scene of repose and tranquil beauty. Its waters, which when surveyed from the precipice, afforded a muddy greenish hue, arising from their depth and position to the eye,* when regarded from a shelving shore, wear the colour of the sky, and seem rising to meet it. The deafening noise of the deep sea is here converted into gentle murmurs; instead of the water's dashing against the face of the rock, it advances and recedes, still going forward, but with just force enough to push its weeds and shells, by insensible approaches, to the shore.

There are other shores, beside those already described, which either have been raised by art to oppose the sea's approaches, or, from the sea's gaining ground, are threatened with imminent destruction. The sea's being thus seen to give and take away lands at pleasure, is, without question, one of the most extraordinary considerations in all natural history. In some places it is seen to obtain the superiority by slow and certain approaches; or to burst in at once, and overwhelm all things in undistinguished destruction; in other places it departs from its shores, and where its waters have

* Newton's Optics, p. 163—167.

been known to rage, it leaves fields covered with the most beautiful verdure.

The formation of new lands, by the sea's continually bringing its sediment to one place, and by the accumulation of its sands in another, is easily conceived. We have had many instances of this in England. The island of Oxney, which is adjacent to Romney marsh, was produced in this manner. This had for a long time been a low level, continually in danger of being overflown by the river Rother; but the sea, by its depositions, has gradually raised the bottom of the river, while it has hollowed the mouth; so that the one is sufficiently secured from inundations, and the other is deep enough to admit ships of considerable burthen. The like also may be seen at that bank called the Dogger-sands, where two tides meet, and which thus receives new increase every day, so that in time the place seems to promise fair for being habitable earth. On many parts of the coasts of France, England, Holland, Germany, and Prussia, the sea has been sensibly known to retire.* Hubert Thomas asserts, in his Description of the country of Liege, that the sea formerly encompassed the city of Tongres, which, however, is at present thirty-five leagues distant from it: this assertion he supports by many strong reasons; and among others, by the iron rings fixed in the walls of the town, for fastening the ships that came into the port. In Italy there is a considerable piece of ground gained at the mouth of the river Arno; and Ravenna, that once stood by the sea side, is now considerably re-

* Buffon, vol. vi. p. 424.

moved from it. But we need scarcely mention these, when we find that the whole republic of Holland seems to be a conquest upon the sea, and in a manner rescued from its bosom. The surface of the earth, in this country, is below the level of the bed of the sea: and I remember, upon approaching the coast, to have looked down upon it from the sea, as into a valley; however, it is every day rising higher by the depositions made upon it by the sea, the Rhine, and the Meuse; and those parts which formerly admitted large men of war, are now known to be too shallow to receive ships of very moderate burthen.* The province of Jucatan, a peninsula in the gulph of Mexico, was formerly a part of the sea: this tract, which stretches out into the ocean, a hundred leagues, and which is above thirty broad, is every where, at a moderate depth below the surface, composed of shells, which evince that its land once formed the bed of the sea. In France, the town of Aigues Mortes was a port in the times of St. Louis, which is now removed more than four miles from the sea. Psalmodi, in the same kingdom, was an island in the year 815, but is now more than six miles from the shore. All along the coasts of Norfolk, I am very well assured, that, in the memory of man, the sea has gained fifty yards in some places, and has lost as much in others.†

* Buffon, vol. vi. p. 424.

[† The ancient city and see of Dunwich, in Suffolk, which was once a league from the sea, is now nearly eaten up by its encroachments. Of its eight churches, not one is left, and the beach intersecting the church-yard of the cathedral, has exposed to view the graves of its ancient inhabitants. Such is the power of time over all human hope and precaution!]

Thus numerous, therefore, are the instances of new lands having been produced from the sea, which, as we see, is brought about two different ways: first, by the waters raising banks of sand and mud where their sediment is deposited: and secondly, by their relinquishing the shore entirely, and leaving it unoccupied to the industry of man.

But as the sea has been thus known to recede from some lands, so has it, by fatal experience, been found to encroach upon others; and, probably, these depredations on one part of the shore, may account for their dereliction from another; for the current which rested upon some certain bank, having got an egress in some other place, it no longer presses upon its former bed, but pours all its stream into the new entrance, so that every inundation of the sea may be attended with some correspondent dereliction of another shore.

However this be, we have numerous histories of the sea's inundations, and its burying whole provinces in its bosom. Many countries that have been thus destroyed bear melancholy witness to the truth of history; and shew the tops of their houses, and the spires of their steeples, still standing at the bottom of the water. One of the most considerable inundations we have in history, is that which happened in the reign of Henry I. which overflowed the estates of the earl Godwin, and forms now that bank called the Goodwin sands. In the year 1546, a similar irruption of the sea destroyed a hundred thousand persons in the territory of Dort; and yet a greater number round Dullart. In Friezland, and Zealand, there were more than

three hundred villages overwhelmed; and their remains continue still visible at the bottom of the water in a clear day. The Baltic Sea has, by slow degrees, covered a large part of Pomerania; and, among others, destroyed and overwhelmed the famous port of Vineta. In the same manner, the Norwegian Sea has formed several little islands from the main land, and still daily advances upon the continent. The German Sea has advanced upon the shores of Holland, near Catt; so that the ruins of an ancient citadel of the Romans, which was formerly built upon this coast, are now actually under water. To these accidents several more might be added; our own historians, and those of other countries, abound with them; almost every flat shore of any extent being able to shew something that it has lost, or something that it has gained from the sea.

There are some shores on which the sea has made temporary depredations; where it has overflowed, and after remaining perhaps some ages, it has again retired of its own accord, or been driven back by the industry of man.* There are many lands in Norway, Scotland, and the Maldivia islands, that are at one time covered with water, and at another free. The country round the Isle of Ely, in the times of Bede, about a thousand years ago, was one of the most delightful spots in the whole kingdom. It was not only richly cultivated, and produced all the necessaries of life, but grapes also that afforded excellent wine. The accounts of that time are copious in the description of its verdure

* Buffon, vol. ii. p. 425.

and fertility; its rich pastures, covered with flowers and herbage; its beautiful shades, and wholesome air. But the sea breaking in upon the land, overwhelmed the whole country, took possession of the soil, and totally destroyed one of the most fertile vallies in the world. Its air, from being dry and healthful, from that time became most unwholesome, and clogged with vapours; and the small part of the country that, by being higher than the rest, escaped the deluge, was soon rendered uninhabitable, from its noxious vapours. Thus this country continued under water for some centuries; till, at last, the sea, by the same caprice which had prompted its invasions, began to abandon the earth in like manner. It has continued for some ages to relinquish its former conquests; and although the inhabitants can neither boast the longevity, nor the luxuries of their former pre-occupants, yet they find ample means of subsistence; and if they happen to survive the first years of their residence there, they are often known to arrive at a good old age.

But although history be silent as to many other inundations of the like kind, where the sea has overflowed the country, and afterwards retired, yet we have numberless testimonies of another nature, that prove it beyond the possibility of doubt: I mean those numerous trees that are found buried at considerable depths in places where either rivers or the sea has accidentally overflown.* At the mouth of the river Ness, near Bruges, in Flanders, at the depth of fifty feet, are found great quantities of

* Buffon, vol. ii. p. 403.

trees lying as close to each other as they do in a wood: the trunks, the branches, and the leaves, are in such perfect preservation, that the particular kind of each tree may instantly be known. About five hundred years ago, this very ground was known to have been covered by the sea; nor is there any history or tradition of its having been dry ground, which we can have no doubt must have been the case. Thus we see a country flourishing in verdure, producing large forests, and trees of various kinds, overwhelmed by the sea. We see this element depositing its sediment to a height of fifty feet; and its waters must, therefore, have risen much higher. We see the same, after it has thus overwhelmed and sunk the land so deep beneath its slime, capriciously retiring from the same coasts, and leaving that habitable once more, which it had formerly destroyed. All this is wonderful; and, perhaps, instead of attempting to inquire after the cause, which has hitherto been inscrutable, it will best become us to rest satisfied with admiration.

At the city of Modena in Italy, and about four miles round it, wherever it is dug, when the workmen arrive at the depth of sixty-three feet, they come to a bed of chalk, which they bore with an augre five feet deep: they then withdraw from the pit, before the augre is removed, and upon its extraction, the water bursts up through the aperture with great violence, and quickly fills this new-made well, which continues full, and is affected neither by rains nor droughts. But that which is most remarkable in this operation, is the layers of earth as we descend. At the depth of fourteen feet, are found the ruins of an ancient city, paved streets,

houses, floors, and different pieces of Mosaic. Under this is found a solid earth, that would induce one to think had never been removed; however, under it is found a soft oozy earth, made up of vegetables; and at twenty-six feet depth, large trees entire, such as walnut-trees, with the walnuts still sticking on the stem, and their leaves and branches in exact preservation. At twenty-eight feet deep, a soft chalk is found, mixed with a vast quantity of shells; and this bed is eleven feet thick. Under this, vegetables are found again, with leaves and branches of trees as before; and thus alternately chalk and vegetable earth to the depth of sixty-three feet. These are the layers wherever the workmen attempt to bore; while in many of them, they also find pieces of charcoal, bones, and bits of iron. From this description, therefore, it appears, that this country has been alternately overflowed and deserted by the sea, one age after another: nor were these overflowings and retirings of trifling depth, or of short continuance. When the sea burst in, it must have been a long time in overwhelming the branches of the fallen forest with its sediments; and still longer in forming a regular bed of shells eleven feet over them. It must have, therefore, taken an age, at least, to make any one of these layers; and we may conclude, that it must have been many ages employed in the production of them all. The land, also, upon being deserted, must have had time to grow compact, to gather fresh fertility, and to be drained of its waters before it could be disposed to vegetation; or before its trees could have shot forth again to maturity.

We have instances nearer home of the same kind,

given us in the Philosophical Transactions; one of them by Mr. Derham. An inundation of the sea at Dagenham, in Essex, laying bare a part of the adjacent pasture, for above two hundred feet wide, and, in some places, twenty deep, it discovered a number of trees that had lain there for many ages before; these trees, by laying long under ground, were become black and hard, and their fibres so tough, that one might as easily break a wire, as any of them: they lay so thick in the place where they were found, that in many parts he could step from one to another: he conceived, also, that not only all the adjacent marshes, for several hundred acres, were covered underneath with such timber, but also the marshes along the mouth of the Thames, for several miles. The meeting with these trees, at such depths, he ascribes to the sediment of the river, and the tides, which constantly washing over them, have always left some part of their substance behind, so as, by repeated alluvions, to work a bed of vegetable earth over them, to the height at which he found it.

The levels of Hatfield-Chace, in Yorkshire, a tract of above eighteen thousand acres, which was yearly overflown, was reduced to arable and pasture land, by one Sir Cornelius Vermusden, a Dutchman. At the bottom of this wide extent, are found millions of the roots and bodies of trees, of such as this island either formerly did, or does at present produce. The roots of all stand in their proper postures; and by them, as thick as ever they could grow, the respective trunks of each, some above thirty yards long. The oaks, some of which have been sold for fifteen pounds a-piece, are as black

as ebony, very lasting, and close grained. The ash-trees are as soft as earth, and are commonly cut in pieces by the workmen's spades, and as soon as flung up into the open air, turn to dust. But all the rest, even the willows themselves, which are softer than the ash, preserve their substance and texture to this very day. Some of the firs appear to have vegetated, even after they were fallen, and to have, from their branches, struck up large trees, as great as the parent trunk. It is observnable, that many of these trees have been burnt, some quite through, some on one side, some have been found chopped and squared, others riven with great wooden wedges, all sufficiently manifesting, that the country which was deluged, had formerly been inhabited. Near a great root of one tree were found eight coins of the Roman emperors; and in some places, the marks of the ridge and furrow were plainly perceivable, which testified that the ground had formerly been patient of cultivation.

The learned naturalist who has given this description,* has pretty plainly evinced, that this forest, in particular, must have been thus levelled by the Romans; and that the falling of the trees must have contributed to the accumulation of the waters. "The Romans," says he, "when the Britons fled, always pursued them into the fortresses of low woods, and miry forests: in these the wild natives found shelter; and, when opportunity offered, issued out, and fell upon their invaders without mercy. In this manner, the Romans were at length so harassed, that orders were issued out

* Phil. Trans. vol. iv. part ii. p. 214.

for cutting down all the woods and forests in Britain. In order to effect this, and destroy the enemy the easier, they set fire to the woods composed of pines, and other inflammable timber, which spreading, the conflagration destroyed not only the forest, but infinite numbers of the wretched inhabitants who had taken shelter therein. When the pine-trees had thus done what mischief they could, the Romans then brought their army nearer, and, with whole legions of the captive Britons, cut down most of the trees that were yet left standing; leaving only here and there some great trees untouched, as monuments of their fury. These, unneedful of their labour, being destitute of the support of the underwood, and of their neighbouring trees, were easily overthrown by the winds, and, without interruption, remained on the places where they happened to fall.. The forest thus fallen, must necessarily have stopped up the currents, both from land and sea; and turned into great lakes, what were before but temporary streams. The working of the waters here, the consumption and decay of rotten boughs and branches, and the vast increase of water-moss which flourishes upon marshy grounds, soon formed a covering over the trunks of the fallen trees, and raised the earth several feet above its former level. The earth thus every day swelling, by a continual increase from the sediment of the waters, and by the lightness of the vegetable substances of which it was composed, soon overtopt the waters by which this intumescence was at first effected; so that it entirely got rid of its inundations, or only demanded a slight assistance from man for that purpose."

This may be the origin of all bogs, which are formed by the putrefaction of vegetable substances, mixed with the mud and slime deposited by waters, and at length acquiring a sufficient consistency.

From this we see what powerful effects the sea is capable of producing upon its shores, either by overflowing some or deserting others; by altering the direction of these, and rendering those craggy and precipitate, which before were shelving. But the influence it has upon these is nothing to that which it has upon that great body of earth which forms its bottom. It is at the bottom of the sea that the greatest wonders are performed, and the most rapid changes are produced; it is there that the motion of the tides and the currents have their whole force, and agitate the substances of which their bed is composed. But all these are almost wholly hid from human curiosity: the miracles of the deep are performed in secret; and we have but little information from its abysses, except what we receive by inspection at very shallow depths, or by the plummet, or from divers, who are known to descend from twenty to thirty fathom.*

The eye can reach but a very short way into the depths of the sea; and that only when its surface is glassy and serene. In many seas it perceives nothing but a bright sandy plain at bottom, extending for several hundred miles, without an intervening object. But in others, particularly in the Red Sea, it is very different: the whole bottom of this extensive bed of waters is, literally speaking, a

* Phil. Trans. vol. iv. part ii. p. 192.

forest of sub-marine plants, and corals formed by insects for their habitation, sometimes branching out to a great extent. Here are seen the madrepores, the sponges, mosses, sea-mushrooms, and other marine productions, covering every part of the bottom; so that some have even supposed the sea to have taken its name from the colour of its plants below. However, these plants are by no means peculiar to this sea, as they are found in great quantities in the Persian gulph, along the coast of Africa, and those of Provence and Catalonia.

The bottom of many parts of the sea near America presents a very different, though a very beautiful appearance. This is covered with vegetables, which make it look as green as a meadow, and beneath are seen thousands of turtles, and other sea-animals, feeding thereon.

In order to extend our knowledge of the sea to greater depths, recourse has been had to the plummet; which is generally made of a lump of lead of about forty pounds weight, fastened to a cord.* This, however, only answers in moderate depths; for when a deep sea is to be sounded, the matter of which the cord is composed, being lighter than the water, floats upon it, and when let down to a considerable depth, its length so increases its surface, that it is often sufficient to prevent the lead from sinking; so that this may be the reason why some parts of the sea are said to have no bottom.

In general, we learn from the plummet, that the

* Boyle, vol. ii. p. 5.

bottom of the sea is tolerably even where it has been examined; and that the farther from the shore, the sea is in general the deeper. Notwithstanding, in the midst of a great and unfathomable ocean, we often find an island raising its head, and singly braving its fury. Such islands may be considered as the mountains of the deep; and, could we for a moment imagine the waters of the ocean removed, or dried away, we should probably find the inequalities of its bed resembling those that are found at land. Here extensive plains; there valleys; and, in many places, mountains of amazing height. M. Buache has actually given us a map of that part of its bottom, which lies between Africa and America, taken from the several soundings of mariners: in it we find the same uneven surface that we do upon land, the same eminences, and the same depressions. In such an imaginary prospect, however, there would be this difference, that as the tops of land-mountains appear the most barren and rocky, the tops of sea-mountains would be found the most verdant and fruitful.

The plummet, which thus gives us some idea of the inequalities of the bottom, leaves us totally in the dark as to every other particular; recourse, therefore, has been had to divers: these, either being bred up in this dangerous way of life, and accustomed to remain some time under water without breathing, or assisted by means of a diving-bell, have been able to return some confused and uncertain accounts of the places below. In the great diving-bell improved by Dr. Halley, which was large enough to contain five men, and was

supplied with fresh air by buckets, that alternately rose and fell, they descended fifty fathom. In this huge machine, which was let down from the mast of the ship, the doctor himself went down to the bottom, where, when the sea was clear, and especially when the sun shone, he could see perfectly well to write or read, and much more to take up any thing that was underneath: at other times, when the water was troubled and thick, it was as dark as night below, so that he was obliged to keep a candle lighted at the bottom. But there is one thing very remarkable: that the water, which from above was usually seen of a green colour, when looked at from below, appeared to him of a very different one, casting a redness upon one of his hands, like that of damask roses*—a proof of the sea's taking its colour not from any thing floating in it, but from the different reflexions of the rays of light. Upon the whole, the accounts we have received from the bottom, by this contrivance, are but few. We learn from it, and from divers in general, that while the surface of the sea may be deformed by tempests, it is usually calm and temperate below;† that some divers who have gone down when the weather was calm, and came up when it was tempestuous, were surprised at their not perceiving the change at the bottom. This, however, must not be supposed to obtain with regard to the tides, and the currents, as they are seen constantly shifting their bottom; taking their bed with great violence from one place, and depositing it upon another. We are informed, also,

* Newton's Optics, p. 56. † Boyle, vol. iii. p. 242.

by divers, that the sea grows colder in proportion as they descend to the bottom; that as far as the sun's rays pierce, it is influenced by their warmth; but lower, the cold becomes almost intolerable. A person of quality, who had been himself a diver, as Mr. Boyle informs us, declared, that though he seldom descended above three or four fathoms, yet he found it so much colder than near the top, that he could not well endure it; and that being let down in a great diving-bell, although the water could not immediately touch him, he found the air extremely cold upon his first arrival at the bottom.

From divers also we learn, that the sea in many places is filled with rocks at bottom: and that among their clifts, and upon their sides, various substances sprout forward, which are either really vegetable, or the nests of insects, increased to some magnitude. Some of these assume the shape of beautiful flowers; and though soft, when taken up, soon harden, and are kept in the cabinets of the curious.

But of all those divers who have brought us information from the bottom of the deep, the famous Nicola Pesce, whose performances are told us by Kircher, is the most celebrated. I will not so much as pretend to vouch for the veracity of Kircher's account, which he assures us he had from the archives of the kings of Sicily; but it may serve to enliven a heavy chapter. "In the times of Frederic, king of Sicily, there lived a celebrated diver, whose name was Nicolas, and who, from his amazing skill in swimming, and his perseverance under water, was surnamed the Fish. This man had, from his infancy, been used to the sea; and

earned his scanty subsistence by diving for corals and oysters, which he sold to the villagers on shore. His long acquaintance with the sea, at last, brought it to be almost his natural element. He frequently was known to spend five days in the midst of the waves, without any other provisions than the fish which he caught there, and ate raw. He often swam over from Sicily to Calabria, a tempestuous and dangerous passage, carrying letters from the king. He was frequently known to swim among the gulphs of the Lipari islands, no way apprehensive of danger.

" Some mariners out at sea one day observed something at some distance from them, which they regarded as a sea-monster; but upon its approach, it was known to be Nicolas, whom they took into their ship, when they asked him whither he was going in so stormy and rough a sea, and at such a distance from land; he showed them a packet of letters, which he was carrying to one of the towns of Italy, exactly done up in a leather bag, in such a manner as that they could not be wetted by the sea. He kept them thus company for some time on their voyage, conversing and asking questions; and after eating a hearty meal with them, he took his leave, and jumping into the sea, pursued his voyage alone.

" In order to aid these powers of enduring in the deep, nature seemed to have assisted him in a very extraordinary manner; for the spaces between his fingers and toes were webbed as in a goose; and his chest became so very capacious, that he could take in at one inspiration as much breath as would serve him for a whole day.

"The account of so extraordinary a person did not fail to reach the king himself; who, actuated by the general curiosity, ordered that Nicolas should be brought before him. It was no easy matter to find Nicolas, who generally spent his time in the solitudes of the deep; but at last, however, after much searching, he was found, and brought before his majesty. The curiosity of this monarch had been long excited by the accounts he had heard of the bottom of the gulph of Charybdis; he therefore conceived that it would be a proper opportunity to have more certain information; and commanded our poor diver to examine the bottom of this dreadful whirlpool: as an incitement to his obedience, he ordered a golden cup to be flung into it. Nicolas was not insensible of the danger to which he was exposed; dangers best known only to himself; and he therefore presumed to remonstrate: but the hopes of the reward, the desire of pleasing the king, and the pleasure of showing his skill, at last prevailed. He instantly jumped into the gulph, and was swallowed as instantly up in its bosom. He continued for three quarters of an hour below; during which time the king and his attendants remained upon shore anxious for his fate; but he at last appeared, buffeting upon the surface, holding the cup in triumph in one hand, and making his way good among the waves with the other. It may be supposed he was received with applause, upon his arrival on shore: the cup was made the reward of his adventure; the king ordered him to be taken proper care of; and as he was somewhat fatigued and debilitated

by his labour, after a hearty meal, he was put to bed, and permitted to refresh himself by sleeping.

"When his spirits were thus restored, he was again brought to satisfy the king's curiosity with a narrative of the wonders he had seen; and his account was to the following effect: He would never, he said, have obeyed the king's commands had he been apprized of half the dangers that were before him. There were four things, he said, that rendered the gulph dreadful, not only to men, but even to the fishes themselves: first, the force of the water bursting up from the bottom, which requires great strength to resist; 2dly, the abruptness of the rocks, that on every side threatened destruction; thirdly, the force of the whirlpool, dashing against those rocks; and fourthly, the number and magnitude of the polypous fish, some of which appeared as large as a man, and which every where sticking against the rocks, projected their fibrous arms to entangle him. Being asked how he was able so readily to find the cup that had been thrown in, he replied, that it happened to be flung by the waves into the cavity of a rock, against which he himself was urged in his descent. This account, however, did not satisfy the king's curiosity: being requested to venture once more into the gulph for further discoveries, he at first refused; but the king, desirous of having the most exact information possible of all things to be found in the gulph, repeated his solicitations; and, to give them still greater weight, produced a larger cup than the former, and added also a purse of gold. Upon these considerations, the unfor-

tunate Pessacola once again plunged into the whirlpool, and was never heard of more."

CHAP. XVIII.

A summary Account of the Mechanical Properties of Air.

HAVING described the earth and the sea, we now ascend into that fluid which surrounds them both; and which, in some measure, supports and supplies all animated nature. As, upon viewing the bottom of the ocean from its surface, we see an infinity of animals moving therein, and seeking food; so, were some superior being to regard the earth at a proper distance, he might consider us in the same light: he might from his superior station, behold a number of busy little beings, immersed in the aërial fluid, that every where surrounds them, and sedulously employed in procuring the means of subsistence. This fluid, though too fine for the gross perception of its inhabitants, might, to his nicer organs of sight, be very visible; and, while he at once saw into its operations, he might smile at the varieties of human conjecture concerning it: he might readily discern, perhaps, the height above the surface of the earth to which this fluid atmosphere reaches: he might exactly determine the peculiar form of its parts which gives it the spring or elasticity with which it is endued: he might distinguish which of its parts were pure incorruptible air, and which only made for a little time to assume the appearance, so

as to be quickly returned back to the element from whence it came. But as for us, who are immersed at the bottom of this gulph, we must be contented with a more confined knowledge; and, wanting a proper point of prospect, remain satisfied with a combination of the effects.

One of the first things that our senses inform us of is, that although the air is too fine for our sight, it is very obvious to our touch. Although we cannot see the wind contained in a bladder, we can very readily feel its resistance; and though the hurricane may want colour, we often fatally experience that it does not want force. We have equal experience of the air's spring or elasticity: the bladder, when pressed, returns again, upon the pressure being taken away; a bottle, when filled, often bursts, from the spring of air which is included.

So far the slightest experience reaches; but, by carrying experiment a little farther, we learn that air also is heavy: a round glass vessel being emptied of its air, and accurately weighed, has been found lighter than when it was weighed with the air in it. Upon computing the superior weight of the full vessel, a cubic foot of air is found to weigh something more than an ounce.

From this experiment, therefore, we learn, that the earth, and all things upon its surface, are every where covered with a ponderous fluid, which rising very high over our heads, must be proportionably heavy. For instance, as in the sea, a man at the depth of twenty feet sustains a greater weight of water than a man at the depth of but ten feet; so will a man at the bottom of a valley

have a greater weight of air over him, than a man on the top of a mountain.

Hence we may conclude, that we sustain a very great weight of air; and although, like men walking at the bottom of the sea, we cannot feel the weight which presses equally round us, yet the pressure is not the less real. As in morals we seldom know the blessings that surround us till we are deprived of them, so here we do not perceive the weight of the ambient fluid, till a part of it is taken away. If, by any means, we contrive to take away the pressure of the air from any one part of our bodies, we are soon made sensible of the weight upon the other parts. If we clap our hand upon the mouth of a vessel from whence the air has been taken away, there will thus be air on one side, and none on the other; upon which, we shall instantly find the hand violently sucked inwards, which is nothing more than the weight of the air upon the back of the hand that forces it into the space which is empty below.

As by this experiment we perceive that the air presses with great weight upon every thing on the surface of the earth, so by other experiments we learn the exact weight with which it presses. First, if the air be exhausted out of any vessel, a drinking vessel for instance,* and this vessel be set with the mouth downwards in water, the water will rise up into the empty space, and fill the inverted glass; for the external air will, in this case, press up the water where there is no weight to

* This may be done by burning a bit of paper in the same, and then quickly turning it down upon the water.

†

resist; as, one part of a bed being pressed, makes the other parts, that have no weight upon them, rise. In this case, as was said, the water being pressed without, will rise in the glass; and would continue to rise (if the empty glass were tall enough) thirty-two feet high. In fact, there have been pipes made purposely for this experiment of above thirty-two feet high; in which, upon being exhausted, the water has always risen to the height of thirty-two feet: there it has always rested, and never ascended higher. From this, therefore, we learn, that the weight of the air which presses up the water, is equal to a pillar or column of water which is thirty-two feet high; as it is just able to raise such a column, and no more. In other words, the surface of the earth is every where covered with a weight of air, which is equivalent to a covering of thirty-two feet deep of water; or to a weight of twenty-nine inches and a half of quicksilver, which is known to be just as heavy as the former.

Thus we see that the air at the surface of the earth is just as heavy as thirty-two feet of water, or twenty-nine inches and a half of quicksilver; and it is easily found, by computation, that to raise water thirty-two feet will require a weight of fifteen pounds upon every square inch. Now, if we are fond of computations, we have only to calculate how many square inches are in the surface of an ordinary human body, and allowing every inch to sustain fifteen pounds, we may amaze ourselves at the weight of air we sustain. It has been computed, and found, that our ordinary load of air amounts to within a little of forty thousand

pounds: this is wonderful! but wondering is not the way to grow wise.

Notwithstanding this be our ordinary load, and our usual supply, there are at different times very great variations. The air is not, like water, equally heavy at all seasons; but sometimes is lighter and sometimes more heavy. It is sometimes more comprest, and sometimes more elastic or springy, which produces the same effects as an increase of its weight. The air which at one time raises water thirty-two feet in the tube, and quicksilver twenty-nine inches, will not at another raise the one to thirty feet, or the other to twenty-six inches. This makes, therefore, a very great difference in the weight we sustain; and we are actually known, by computation, to carry at one time four thousand pounds of air more than at another.

The reason of this surprising difference in the weight of air, is either owing to its pressure from above, or to an increase of vapour floating in it. Its increased pressure is the consequence of its spring or elasticity, which cold and heat sensibly affect, and are continually changing.

This elasticity of the air is one of its most amazing properties; and to which it should seem nothing can set bounds. A body of air that may be contained in a nut-shell, may easily, with heat, be dilated into a sphere of unknown dimensions. On the contrary, the air contained in a house, may be compressed into a cavity not larger than the eye of a needle. In short, no bounds can be set to its confinement or expansion; at least, experiment has hitherto found its attempts indefinite. In every situation, it retains its elasticity; and the more

closely we compress it, the more strongly does it resist the pressure. If to the increasing the elasticity on one side by compression, we increase it or the other side by heat, the force of both soon becomes irresistible; and a certain French philosopher supposed,* that air thus confined, and expanding, was sufficient for the explosion of a world.

Many instruments have been formed to measure and determine these different properties of the air; and which serve several useful purposes. The barometer serves to measure its weight; to tell us when it is heavier, and when lighter. It is composed of a glass tube or pipe, of about thirty inches in length, closed up at one end; this tube is then filled with quicksilver; this done, the maker, clapping his finger upon the open end, inverts the tube, and plunges the open end, finger and all, into a bason of quicksilver, and then takes his finger away: now the quicksilver in the tube will, by its own weight, endeavour to descend into that in the bason; but the external air, pressing on the surface of the quicksilver in the bason without, and no air being in the tube at top, the quicksilver will continue in the tube, being pressed up, as was said, by the air, on the surface of the bason below. The height at which it is known to stand in the tube, is usually about twenty-nine inches, when the air is heavy; but not above twenty-six, when the air is very light. Thus, by this instrument we can, with some exactness, determine the weight of the air; and, of consequence, tell, before-hand, the changes of the weather. Before fine dry weather,

* Monsieur Amontons.

the air is charged with a variety of vapours, which float in it unseen, and render it extremely heavy, so that it presses up the quicksilver; or, in other words, the barometer rises. In moist, rainy weather, the vapours are washed down, or there is not heat sufficient for them to rise, so that the air is then sensibly lighter, and presses up the quicksilver with less force; or, in other words, the barometer is seen to fall. Our constitutions seem also to correspond with the changes of the weather-glass; they are braced, strong, and vigorous, with a large body of air upon them; they are languid, relaxed, and feeble, when the air is light, and refuses to give our fibres their proper tone.

But although the barometer thus measures the weight of the air with exactness enough for the general purposes of life, yet it is often affected with a thousand irregularities, that no exactness in the instrument can remedy, nor no theory account for. When high winds blow, the quicksilver generally is low: it rises higher in cold weather than in warm; and is usually higher at morning and evening than at mid-day: it generally descends lower after rain than it was before it. There are also frequent changes in the air, without any sensible alteration in the barometer.

As the barometer is thus used in predicting the changes of the weather, so it is also serviceable in measuring the heights of mountains, which mathematicians cannot so readily do: for as, the higher we ascend from the surface of the earth, the air becomes lighter, so the quicksilver in the barometer will descend in proportion. It is found to sink at the rate of the tenth part of an inch for every ninety

feet we ascend; so that in going up a mountain, if I find the quicksilver fallen an inch, I conclude, that I am got upon an ascent of near nine hundred feet high. In this there has been found some variation; into a detail of which, it is not the business of a natural historian to enter.

In order to determine the elasticity of air, the wind-gun has been invented, which is an instrument variously made; but in all upon the principle of compressing a large quantity of air into a tube, in which there is an ivory ball, and then giving the compressed elastic air free power to act, and drive the ball as directed. The ball thus driven, will pierce a thick board: and will be as fatal, at small distances, as if driven with gunpowder. I do not know whether ever the force of this instrument has been assisted by means of heat; certain I am, that this, which could be very easily contrived by means of phosphorus, or any other hot substance applied to the barrel, would give such a force as I doubt whether gunpowder itself could produce.

The air-pump is an instrument contrived to exhaust the air from round a vessel adapted to that purpose, called a receiver. This method of exhausting, is contrived in the simple instrument, by a piston, like that of a syringe, going down into the vessel, and thus pushing out its air; which, by means of a valve, is prevented from returning into the vessel again. But this, like all other complicated instruments, will be better understood by a minute inspection, than an hour's description; it may suffice here to observe, that by depriving animals, and other substances, of all air, it shows us

what the benefits and effects of air are in sustaining life, or promoting vegetation.

The digester is an instrument of still more extraordinary effects than any of the former; and sufficiently discovers the amazing force of air, when its elasticity is augmented by fire. A common tea-kettle, if the spout were closed up, and the lid put firmly down, would serve to become a digester, if strong enough. But the instrument used for this purpose is a strong metal pot, with a lid to screw close on, so that, when down, no air can get in or return: into this pot meat and bones are put, with a small quantity of water, and then the lid screwed close: a lighted lamp is put underneath, and, what is very extraordinary (yet equally true) in six or eight minutes the whole mass, bones and all, are dissolved into a jelly; so great is the force and elasticity of the air contained within, struggling to escape, and breaking in pieces all the substances with which it is mixed. Care, however, must be taken not to heat this instrument too violently; for then, the inclosed air would become irresistible, and burst the whole, with perhaps a fatal explosion.

There are numberless other useful instruments made to depend on the weight, the elasticity, or the fluidity of the air, which do not come within the plan of the present work; the design of which is not to give an account of the inventions that have been made, for determining the nature and properties of air, but a mere narrative of its effects. The description of the pump, the forcing-pump, the fire-engine, the steam-engine, the syphon, and many others, belong not to the naturalist, but the

experimental philosopher: the one gives a history of Nature, as he finds she presents herself to him; and he draws the obvious picture: the other pursues her with close investigation, tortures her by experiment to give up her secrets, and measures her latent qualities with laborious precision. Much more, therefore, might be said of the mechanical effects of air, and of the conjectures that have been made respecting the form of its parts; how some have supposed them to resemble little hoops coiled up in a spring; others like fleeces of wool; others, that the parts are endued with a repulsive quality, by which, when squeezed together, they endeavour to fly off, and recede from each other. We might have given the disputes relative to the height to which this body of air extends above us, and concerning which there is no agreement. We might have inquired how much of the air we breathe is elementary, and not reducible to any other substance; and of what density it would become, if it were supposed to be continued down to the centre of the earth. At that place we might, with the help of figures, and a bold imagination, have shown it twenty thousand times heavier than its bulk of gold. We might also prove it millions of times purer than upon earth, when raised to the surface of the atmosphere. But these speculations do not belong to natural history; and they have hitherto produced no great advantages in that branch of science to which they more properly appertain.

CHAP. XIX.

An Essay towards a Natural History of the Air.

A LATE eminent philosopher has considered our atmosphere as one large chemical vessel, in which an infinite number of various operations are constantly performing. In it all the bodies of the earth are continually sending up a part of their substance by evaporation, to mix in this great alembic, and to float a-while in common. Here minerals, from their lowest depths, ascend in noxious, or in warm vapours, to make a part of the general mass; seas, rivers, and subterranean springs, furnish their copious supplies; plants receive and return their share; and animals, that by living upon, consume this general store, are found to give it back in greater quantities, when they die.* The air, therefore, that we breathe, and upon which we subsist, bears very little resemblance to that pure elementary body which was described in the last chapter; and which is rather a substance that may be conceived, than experienced to exist. Air, such as we find it, is one of the most compounded bodies in all nature. Water may be reduced to a fluid every way resembling air, by heat; which, by cold, becomes water again. Every thing we see gives off its parts to the air, and has a little floating atmosphere of its own round it. The rose is encompassed with a sphere of its own odorous particles; while

* Boyle, vol. ii. p. 593.

the night-shade infects the air with a scent of a more ungrateful nature. The perfume of musk flies off in such abundance, that the quantity remaining becomes sensibly lighter by the loss. A thousand substances that escape all our senses, we know to be there; the powerful emanations of the load-stone, the effluvia of electricity, the rays of light, and the insinuations of fire. Such are the various substances through which we move, and which we are constantly taking in at every pore, and returning again with imperceptible discharge!

This great solution, or mixture of all earthly bodies, is continually operating upon itself; which, perhaps, may be the cause of its unceasing motion: but it operates still more visibly upon such grosser substances as are exposed to its influence; for scarcely any substance is found capable of resisting the corroding qualities of the air. The air, say the chemists, is a chaos furnished with all kinds of salts and menstruums; and, therefore, it is capable of dissolving all kinds of bodies. It is well known, that copper and iron are quickly covered, and eaten with rust; and that, in the climates near the equator, no art can keep them clean. In those dreary countries, the instruments, knives and keys, that are kept in the pocket, are nevertheless quickly incrusted; and the great guns, with every precaution, after some years, become useless. Stones, as being less hard, may be readily supposed to be more easily soluble. The marble of which the noble monuments of Italian antiquity are composed, although in one of the finest climates in the world, show the impressions which have been made upon them by the air. In many places they seem worm-eaten by

time; and, in others, they appear crumbling into dust. Gold alone seems to be exempted from this general state of dissolution; it is never found to contract rust, though exposed never so long: the reason of this seems to be, that sea-salt, which is the only menstruum capable of acting upon, and dissolving gold, is but very little mixed with the air; for salt being a very fixed body, and not apt to volatilize, and rise with heat, there is but a small proportion of it in the atmosphere. In the elaboratories, and shops, however, where salt is much used, and the air is impregnated with it, gold is found to rust as well as other metals.

Bodies of a softer nature are obviously destroyed by the air.* Mr. Boyle says, that silks brought to Jamaica, will, if there exposed to the air, rot even while they preserve their colour; but if kept therefrom, they both retain their strength and gloss. The same happens in Brasil, where their clothes, which are black, soon turn of an iron colour; though, in the shops, they preserve their proper hue.† In these tropical climates also, such are the putrescent qualities of the air, that white sugar will sometimes be full of maggots. Drugs and plasters lose their virtue, and become verminous. In some places they are obliged to expose their sweetmeats by day in the sun, otherwise the night air would quickly cause them to putrefy. On the contrary, in the cold arctic regions, animal substances, during their winter, are never known to putrefy; and meat may be kept for months, without any salt whatsoever. This experiment

* Buffon, vol. iii. p. 62. † Ibid. vol. iii. p. 68.

happily succeeded with the eight Englishmen that were accidentally left upon the inhospitable coasts of Greenland, at a place where seven Dutchmen had perished but a few years before; for killing some rein-deer for their subsistence, and having no salt to preserve the flesh, to their great surprise, they soon found it did not want any, as it remained sweet during their eight months continuance upon that shore.

These powers, with which air is endued over unorganized substances, are exerted in a still stronger manner over plants, animals of an inferior nature, and, lastly, over man himself. Most of the beauty, and the luxuriance of vegetation, is well known to be derived from the benign influence of the air; and every plant seems to have its favourite climate, not less than its proper soil. The lower ranks of animals also seem formed for their respective climates, in which only they can live. Man alone seems the child of every climate, and capable of existing in all. However, this peculiar privilege does not exempt him from the influences of the air; he is as much subject to its malignity, as the meanest insect or vegetable.

With regard to plants, air is so absolutely necessary for their life and preservation, that they will not vegetate in an exhausted receiver. All plants have within them a quantity of air, which supports and agitates their juices. They are continually imbibing fresh nutriment from the air, to increase this store, and to supply the wants which they sustain from evaporation. When, therefore, the external air is drawn from them, they are no longer able to subsist. Even that quantity of

air which they before were possessed of, escapes through their pores, into the exhausted receiver: and as this continues to be pumped away, they become languid, grow flaccid, and die. However, the plant or flower thus ceasing to vegetate, is kept, by being secured from the external air, a much longer time sweet than it would have continued, had it been openly exposed.

That air which is so necessary to the life of vegetables, is still more so to that of animals; there are none found, how seemingly torpid soever, that do not require their needful supply. Fishes themselves will not live in water from whence the air is exhausted; and it is generally supposed that they die in frozen ponds, from the want of this necessary to animal existence. Many have been the animals that idle curiosity has tortured in the prison of a receiver, merely to observe the manner of their dying. We shall, from a thousand instances, produce that of the viper, as it is known to be one of the most vivacious reptiles in the world; and as we shall feel but little compassion for its tortures. Mr. Boyle took a new-caught viper, and shutting it up into a small receiver, began to pump away the air.* "At first, upon the air's being drawn away, it began to swell; some time after he had done pumping, it began to gape, and open its jaws; being thus compelled to open its jaws, it once more resumed its former lankness; it then began to move up and down within, as if to seek for air, and after a while foamed a little, leaving the foam sticking to the inside of the glass; soon after the

* Boyle's Physico-Mechan. Exper. passim.

body and neck grew prodigiously tumid, and a blister appeared upon its back; an hour and a half after the receiver was exhausted, the distended viper moved, and gave manifest signs of life; the jaws remained quite distended; as it were from beneath the epiglottis, came the black tongue, and reached beyond it; but the animal seemed, by its posture, not to have any life: the mouth also was grown blackish within; and in this situation it continued for twenty-three hours. But upon the air's being re-admitted, the viper's mouth was presently closed, and soon after opened again: and for some time those motions continued, which argued the remains of life." Such is the fate of the most insignificant or minute reptile that can be thus included. Mites, fleas, and even the little eels that are found swimming in vinegar, die for want of air. Not only these, but the eggs of these animals, will not produce in vacuo, but require air to bring them to perfection.

As in this manner air is necessary to their subsistence, so also it must be of a proper kind, and not impregnated with foreign mixtures. That factitious air which is pumped from plants or fluids, is generally, in a short time, fatal to them. Mr. Boyle has given us many experiments to this purpose. After having shown that all vegetable, and most mineral substances, properly prepared, may afford air, by being placed in an exhausted receiver, and this in such quantities, that some have thought it a new substance, made by the alteration which the mineral plant has undergone by the texture of its parts being loosened in the operation—having shown, I say, that this air may be drawn in great

quantities from vegetable, animal, or mineral substances, such as apples, cherries, amber burnt, or hartshorn*—he included a frog in artificial air, produced from paste; in seven minutes space it suffered convulsions, and at last lay still, and being taken out, recovered no motion at all, but was dead. A bird inclosed in artificial air, from raisins, died in a quarter of a minute, and never stirred more. A snail was put into the receiver, with air of paste; in four minutes it ceased to move, and was dead, although it had survived in vacuo for several hours: so that factitious air proved a greater enemy to animals than even a vacuum itself.

Air also may be impregnated with fumes that are instantly fatal to animals. The fumes of hot iron, copper, or any other heated metal, blown into the place where an animal is confined, instantly destroy it. We have already mentioned the vapours in the grotto Del Cane suffocating a dog. The ancients even supposed, that these animals, as they always ran with their noses to the ground, were the first that felt any infection. In short, it should seem that the predominance of any one vapour, from any body, how wholesome soever in itself, becomes infectious; and that we owe the salubrity of the air to the variety of its mixture.†

* Boyle's Physico-Mechan. vol. ii. p. 598.

[† The atmospheric air which invests the globe, has been, till the present age, considered as simple and homogeneous; and all its operations to depend on its relative degree of heat, cold, moisture, or dryness: but it is in fact the receptacle of all kinds of effluvia, produced from terrestrial or marine substances, either naturally or artificially. This atmosphere, excluding all foreign bodies occasionally mixed with it, is found to consist of two com-

But there is no animal whose frame is more sensibly affected by the changes of the air than man. It is true, he can endure a greater variety of climates than the lower orders generally are able to do; but it is rather by the means which he has discovered of obviating their effects, than by the apparent strength of his constitution. Most other animals can bear cold or hunger better, endure greater fatigues in proportion, and are satisfied with shorter repose. The variations of the climate, therefore, would probably affect them the less, if they had the same means or skill in providing against the severities of the change. However this be, the body of man is an instrument much more nicely sensible of the variations of the air, than any of those which his own art has produced; for his frame alone seems to unite all their properties, being invigorated by the weight of the air, relaxed by its moisture, enfeebled by its heat, and stiffened by its frigidity.

But it is chiefly by the predominance of some peculiar vapour, that the air becomes unfit for human support. It is often found, by dreadful experience, to enter into the constitution, to mix with

ponent parts: oxygene, or vital air, necessary for the existence and preservation of animal life and vegetation; and azote, or foul air, immediately destructive of all animal life. The atmosphere in its best state, is found to consist of 74 p. cent. of foul air, and 26 of vital air; and in proportion as one or the other predominates over this combination, it is found more or less fit for animal respiration: the grotto Del Cane and other subterraneous places excluded from the action of the atmospheric air and the rays of light, are filled with foul air, deprived almost entirely of its vital parts.]

its juices, and to putrefy the whole mass of blood. The nervous system is not less affected by its operations; palsies and vertigoes are caused by its damps; and a still more fatal train of distempers by its exhalations. In order that the air should be wholesome, it is necessary, as we have seen, that it should not be of one kind, but the compound of several substances; and the more various the composition, to all appearance the more salubrious. A man, therefore, who continues in one place, is not so likely to enjoy this wholesome variety, as he who changes his situation; and, if I may so express it, instead of waiting for a renovation of air, walks forward to meet its arrival. This mere motion, independent even of the benefits of exercise, becomes wholesome, by thus supplying a great variety of that healthful fluid by which we are sustained.

A thousand accidents are found to increase these bodies of vapour, that make one place more or less wholesome than another. Heat may raise them in too great quantities; and cold may stagnate them. Minerals may give off their effluvia in such proportion as to keep away all other kind of air; vegetables may render the air unwholesome by their supply; and animal putrefaction seems to furnish a quantity of vapour, at least as noxious as any of the former. All these united, generally make up the mass of respiration, and are, when mixed together, harmless; but any one of them, for a long time singly predominant, becomes at length fatal.

The effects of heat in producing a noxious quality in the air, are well known. Those torrid regions under the Line are always unwholesome. At

Senegal, I am told, the natives consider forty as a very advanced time of life, and generally die of old age at fifty. At Carthagena,* in America, where the heat of the hottest day ever known in Europe is continual, where, during their winter season, these dreadful heats are united with a continual succession of thunder, rain, and tempests, arising from their intenseness, the wan and livid complexions of the inhabitants might make strangers suspect that they were just recovered from some dreadful distemper; the actions of the natives are conformable to their colour; in all their motions there is somewhat relaxed and languid; the heat of the climate even affects their speech, which is soft and slow, and their words generally broken. Travellers from Europe retain their strength and ruddy colour in that climate, possibly for three or four months; but afterwards suffer such decays in both, that they are no longer to be distinguished from the inhabitants by their complexion. However, this languid and spiritless existence is frequently drawled on sometimes even to eighty. Young persons are generally most affected by the heat of climate, which spares the more aged; but all, upon their arrival on the coasts, are subject to the same train of fatal disorders. Few nations have experienced the mortality of these coasts, so much as our own: in our unsuccessful attack upon Carthagena, more than three parts of our army were destroyed by the climate alone; and those that returned from that fatal expedition, found their former vigour irretrievably gone. In our more fortunate expedition,

* Ulloa, vol. i. p. 42.

which gave us the Havannah, we had little reason to boast of our success; instead of a third, not a fifth part of the army were left survivors of their victory, the climate being an enemy that even heroes cannot conquer.

The distempers that thus proceed from the cruel malignity of those climates are many; that, for instance, called the Chapotonadas, carries off a multitude of people; and extremely thins the crews of European ships, whom gain tempts into those inhospitable regions. The nature of this distemper is but little known, being caused in some persons by cold, in others by indigestion. But its effects are far from being obscure; it is generally fatal in three or four days: upon its seizing the patient, it brings on what is there called the black vomit, which is the sad symptom after which none are ever found to recover. Some, when the vomit attacks them, are seized with a delirium, that, were they not tied down, they would tear themselves to pieces, and thus expire in the midst of this furious paroxysm. This disorder, in milder climates, takes the name of the bilious fever, and is attended with milder symptoms, but very dangerous in all.

There are many other disorders incident to the human body, that seem the offspring of heat; but to mention no other, that very lassitude which prevails in all the tropical climates, may be considered as a disease. The inhabitants of India,* says a modern philosopher, sustain an unceasing languor, from the heats of their climate; and are torpid in

* Linnæi Amœnitates, vol. v. p. 444.

the midst of profusion.* For this reason, the great Disposer of Nature has clothed their country with trees of an amazing height, whose shade might defend them from the beams of the sun; and whose continual freshness might, in some measure, temperate their fierceness. From these shades, therefore, the air receives refreshing moisture, and animals a cooling protection. The whole race of savage animals retire, in the midst of the day, to the very centre of the forests, not so much to avoid their enemy man, as to find a defence against the raging heats of the season. This advantage, which arises from shades in torrid climates, may probably afford a solution for that extraordinary circumstance related by Boyle, which he imputes to a different cause. In the island of Ternate, belonging to the Dutch, a place that had been long celebrated for its beauty and healthfulness, the clove-trees grew in such plenty, that they in some measure lessened their own value: for this reason, the Dutch resolved to cut down the forests, and thus to raise the price of the commodity; but they had soon reason to repent of their avarice; for such a change ensued, by cutting down the trees, that the whole island, from being healthy and delightful, having lost its charming shades, became

[* It is now known that plants in general have not only a power of correcting bad air, but of improving common air, in a few hours, when exposed to the light of the sun; but in the night time, or when they are not influenced by the solar rays, they contaminate the air: this is occasioned by their discharging large quantities of vital or pure air in the day time, and absorbing foul air in the night time; for this reason it is, that the night air is so unwholesome, especially in the neighbourhood of trees.]

extremely sickly, and has actually continued so to this day. Boerhaave considered heat so prejudicial to health, that he was never seen to go near a fire.

An opposite set of calamities are the consequence, in climates where the air is condensed by cold. In such places, all that train of distempers which are known to arise from obstructed perspiration, are very common;* eruptions, boils, scurvy, and a loathsome leprosy, that covers the whole body with a scurf, and white putrid ulcers. These disorders also are infectious; and, while they thus banish the patient from society, they generally accompany him to the grave. The men of those climates seldom attain to the age of fifty; but the women, who do not lead such laborious lives, are found to live longer.

The autumnal complaints which attend a wet summer, indicate the dangers of a moist air. The long continuance of an east wind also, shows the prejudice of a dry one. Mineral exhalations, when copious, are every where known to be fatal; and although we probably owe the increase and luxuriance of vegetation to a moderate degree of their warmth, yet the natives of those countries where there are mines in plenty, but too often experience the noxious effects of their vicinity. Those trades also that deal in the preparations of metals of all kinds, are always unwholesome; and the workmen, after some time, are generally seen to labour under palsies, and other nervous complaints. The vapours from some vegetable substances, are well known to

* Krantz's History of Greenland, vol. i. p. 235.

be attended with dangerous effects. The shade of the machinel tree, in America, is said to be fatal; as was that of the juniper, if we may credit the ancients. Those who walk through fields of poppies, or in any manner prepare those flowers for making opium, are very sensibly affected with the drowsiness they occasion. A physician of Mr. Boyle's acquaintance, causing a large quantity of black hellebore to be pounded in a mortar, most of the persons who were in the room, and especially the person who pounded it, were purged by it, and some of them strongly. He also gathered a certain plant in Ireland, which the person who beat it in a mortar, and the physician who was standing near, were so strongly affected by, that their hands and faces swelled to an enormous size, and continued tumid for a long time after.

But neither mineral nor vegetable steams are so dangerous to the constitution, as those proceeding from animal substances, putrefying either by disease or death. The effluvia that come from diseased bodies, propagate that frightful catalogue of disorders which are called infectious. The parts which compose vegetable vapours, and mineral exhalations, seem gross and heavy, in comparison of these volatile vapours, that go to great distances, and have been described as spreading desolation over the whole earth. They fly every where; penetrate every where; and the vapours that fly from a single disease, soon render it epidemic.

The plague is the first upon the list in this class of human calamities. From whence this scourge of man's presumption may have its beginning, is not well known; but we well know that it is pro-

pagated by infection. Whatever be the general state of the atmosphere, we learn, from experience, that the noxious vapours, though but singly introduced at first, taint the air by degrees: every person infected, tends to add to the growing malignity; and, as the disorder becomes more general, the putrescence of the air becomes more noxious, so that the symptoms are aggravated by continuance. When it is said that the origin of this disorder is unknown, it implies, that the air seems to be but little employed in first producing it. There are some countries, even in the midst of Africa, that we learn have never been infected with it; but continue, for centuries, unmolested. On the contrary, there are others, that are generally visited once a year, as in Egypt, which, nevertheless, seems peculiarly blessed with the serenity and temperature of its climate. In the former countries, which are of vast extent, and many of them very populous, every thing should seem to dispose the air to make the plague continual among them. The great heats of the climate, the unwholesomeness of the food, the sloth and dirt of the inhabitants, but, above all, the bloody battles which are continually fought among them, after which heaps of dead bodies are left unburied, and exposed to putrefaction. All these one might think would be apt to bring the plague among them; and yet, nevertheless, we are assured, by Leo Africanus, that in Numidia the plague is not known once in a hundred years; and that in Negroland, it is not known at all. This dreadful disorder, therefore, must have its rise, not from any previous disposition of the air, but from some particular cause, beginning with one indi-

vidual, and extending the malignity, by communication, till at last the air becomes actually tainted by the generality of the infection.*

The plague which spread itself over the whole world, in the year 1346, as we are told by Mezeray, was so contagious, that scarcely a village, or even a house, escaped being infected by it. Before it had reached Europe, it had been for two years travelling from the great kingdom of Cathay, where it began by a vapour most horridly fetid; this broke out of the earth like a subterranean fire, and upon the first instant of its eruption, consumed and desolated above two hundred leagues of that country, even to the trees and stones.

In that great plague which desolated the city of London, in the year 1665, a pious and learned schoolmaster of Mr. Boyle's acquaintance, who ventured to stay in the city, and took upon him the humane office of visiting the sick and the dying,

[* The plague is supposed to have its origin in upper Egypt. After the waters have subsided from the overflowing of the Nile, a putrid exhalation is raised from the slime and carcases of fish and other animals, highly detrimental to animal life: this, with the heat of the weather, and the superstition and filthiness of the inhabitants, soon produces this most malignant of all diseases: and, as no preventive precautions are taken by the gross and idle inhabitants, it soon spreads over the whole of Turkey, Egypt, and Syria; and thence it is communicated by commerce to other parts of the globe. Of its highly infectious nature Dr. Wittman, in his Travels, relates several instances. A brother of the French general Julien died of the plague: he received the infection by taking a pinch of snuff from a box, out of which a person who had the plague on him at the time, had also taken snuff. A pelisse, says he, the property of a Turk who died from the plague, was given to another, who, without fear or thought, put it on

who had been deserted by better physicians, averred, that being once called to a poor woman who had buried her children of the plague, he found the room where she lay so little that it scarcely could hold any more than the bed whereon she was stretched. However, in this wretched abode, beside her, in an open coffin, her husband lay, who had some time before died of the same disease; and whom she, poor creature, soon followed. But what showed the peculiar malignity of the air, thus suffering from animal putrefaction, was, that the contagious steams had produced spots on the very wall of their wretched apartment: and Mr. Boyle's own study, which was contiguous to a pest-house, was also spotted in the same frightful manner. Happily for mankind, this disorder, for more than a century, has not been known in our island; and, for this last age, has abated much of its violence, even in those countries where it is most common. Diseases, like empires, have their revolutions; and those which for a while were the scourge of mankind, sink unheard of, to give place to new ones, more dreadful, as being less understood.

For this revolution in disorders, which has employed the speculation of many, Mr. Boyle accounts in the following manner: "Since," says he, "there want not causes in the bowels of the earth to make considerable changes amongst the materials that nature has plentifully treasured up in those maga-

his back, caught the infection, and quickly died. In this way this pelisse might have passed into the hands of twenty more, with the same apathy and fatal effects.]

zines, and as those noxious steams are abundantly supplied to the surface, it may not seem improbable, that, in this great variety, some may be found capable of affecting the human frame in a particular manner, and thus of producing new diseases. The duration of these may be greater or less, according to the lastingness of those subterraneous causes that produced them. On which account, it need be no wonder that some diseases have but a short duration, and vanish not long after they appear; whilst others may continue longer, as having under ground more settled and durable causes to maintain them."

From the recital of this train of mischiefs produced by the air, upon minerals, plants, animals, and man himself, a gloomy mind may be apt to dread this indulgent nurse of nature as a cruel and an inexorable step-mother: but it is far otherwise; and although we are sometimes injured, yet almost all the comforts and blessings of life spring from its propitious influence. It would be needless to observe, that it is absolutely necessary for the support of our lives; for of this, every moment's experience assures us. But how it contributes to this support, is not so readily comprehended. All allow it to be a friend, to whose benefits we are constantly obliged: and yet, to this hour, philosophers are divided as to the nature of the obligation. The dispute is, whether the air is only useful by its weight to force our juices into circulation;* or, whether, by containing a peculiar spirit, it mixes with the blood in our vessels, and acts like a spur

* Keil, Robinson.

to their industry.* Perhaps it may exert both these useful offices at the same time. Its weight may give the flood its progressive motion, through the larger vessels of the body; and its admixture with it cause those contractions of all the vessels, which serve to force it still more strongly forward, through the minutest channels of the circulation. Be this as it may, it is well known that that part of our blood which has just received the influx of the air in our bodies, is of a very different colour from that which has almost performed its circuit. It has been found, that the arterial blood which has been immediately mixed with the air in the lungs, and, if I may so express it, is just beginning its journey through the body, is of a fine florid scarlet colour; while, on the contrary, the blood of the veins that is returning from having performed its duty, is of a blackish crimson hue. Whence this difference of colour shall proceed, is not well understood; we only know the fact, that this florid colour is communicated by the air; and we are well convinced, that this air has been admitted into the blood for very useful purposes.†

* Whytt upon Vital and Involuntary Motions.

[† By the late discoveries of Dr. Priestley, M. Lavoisier, and other philosophers, it appears that by the function of respiration, the oxygene or vital part of the atmospheric air is received by the blood through the membranes of the lungs, and by means of the heart conveyed through the arterial system, whence it is returned back to the heart through the veins, after having in its passage parted with a considerable portion of its oxygene. By this addition, it likewise appears, that the colour of the blood is changed from a dark to a light florid red: hence we perceive the reason, why the blood in the lungs and arteries is of a bright scarlet red,

Besides this vital principle in animals, the air also gives life and body to flame. A candle quickly goes out in an exhausted receiver; for having soon consumed the quantity of air, it then expires, for want of a fresh supply. There has been a flame contrived that will burn under water: but none has yet been found that will continue to burn without air. Gunpowder, which is the most catching and powerful fire we know, will not go off in an exhausted receiver; nay, if a train of gunpowder be laid, so as that one part may be fired in the open air, yet the other part in vacuo will remain untouched, and unconsumed. Wood also set on fire, immediately goes out, and its flame ceases, upon removing the air; for something is then wanting to press the body of the fire against that of the fuel, and to prevent the too speedy diffusion of the flame. We frequently see cooks, and others, whose business it is to keep up strong fires, take proper precautions to exclude the beams of the sun from

and in the veins of a dark brownish red; and as at every inspiration, a portion of the oxygene of the atmosphere is consumed by the lungs, that which is returned at every expiration must be rendered unfit for the purposes of animal life, and accounts for the difficulty of breathing we find in confined situations, and the impossibility of living long without free access to the atmospheric air. Water possesses oxygene also, as a part of its composition, and contains air in its pores; whence the blood of fish receives oxygene from water or the air contained in it, by means of their gills, in the same manner as the blood is oxygenated in the lungs of air-breathing animals, changing its colour from a dark to a light red in the vessels of their gills, which constitute a pulmonary organ adapted to the medium in which they live. In all combustion, likewise, oxygene is consumed; which shows us why a candle will not burn without a fresh supply of air.]

shining upon them, which effectually puts them out. This they are apt to ascribe to a wrong cause; namely, the operation of the light; but the real fact is, that the warmth of the sun-beams lessens and dissipates the body of the air that goes to feed the flame; and the fire, of consequence, languishes for want of a necessary supply.

The air, while it thus kindles fire into flame, is notwithstanding found to moderate the rays of light, to dissipate their violence, and to spread an uniform lustre over every object. Were the beams of the sun to dart directly upon us, without passing through this protecting medium, they would either burn us up at once, or blind us with their effulgence. But by going through the air, they are reflected, refracted, and turned from their direct course, a thousand different ways; and thus are more evenly diffused over the face of nature.

Among the other necessary benefits the air is of to us, one of the principal is its conveyance of sound. Even the vibrations of a bell, which have the loudest effect that we know of, cease to be heard, when under the receiver of an air-pump. Thus all the pleasures we receive from conversation with each other, or from music, depend entirely upon the air.

Odours likewise are diffused only by the means of air; without this fluid to swim in, they would for ever remain torpid in their respective substances; and the rose would affect us with as little sensations of pleasure, as the thorn on which it grew.

Those who are willing to augment the catalogue of the benefits we receive from this element, assert

also, that tastes themselves would be insipid, were it not that the air presses their parts upon the nerves of the tongue and palate, so as to produce their grateful effects. Thus, continue they, upon the tops of high mountains, as on the Pike of Teneriffe, the most poignant bodies, as pepper, ginger, salt, and spice, have no sensible taste, for want of their particles being thus sent home to the sensory. But we owe the air sufficient obligations, not to be studious of admitting this among the number: in fact, all substances have their taste, as well on the tops of mountains, as in the bottom of the valley; and I have been one of many, who have ate a very savoury dinner on the Alps.

It is sufficient, therefore, that we regard the air as the parent of health and vegetation; as a kind dispenser of light and warmth; and as the conveyer of sounds and odours. This is an element of which avarice will not deprive us; and which power cannot monopolize. The treasures of the earth, the verdure of the fields, and even the refreshments of the stream, are too often seen going only to assist the luxuries of the great; while the less fortunate part of mankind stand humble spectators of their encroachments. But the air no limitations can bound, nor any land-marks restrain. In this benign element, all mankind can boast an equal possession; and for this we all have equal obligations to Heaven. We consume a part of it, for our own sustenance, while we live; and, when we die, our putrefying bodies give back the supply, which, during life, we had accumulated from the general mass.

CHAP. XX.

Of Winds, irregular and regular.

WIND is a current of air. Experimental philosophers produce an artificial wind, by an instrument called an eolipile. This is nothing more than a hollow copper ball, with a long pipe; a tea-kettle might be readily made into one, if it were entirely closed at the lid, and the spout left open; through this spout it is to be filled with water, and then set upon the fire, by which means it produces a violent blast, like wind, which continues while there is any water remaining in the instrument. In this manner water is converted into a rushing air; which, if caught, as it goes out, and left to cool, is again quickly converted into its former element. Besides this, as was mentioned in the former chapter, almost every substance contains some portions of air. Vegetables, or the bodies of animals left to putrefy, produce it in a very copious manner. But it is not only seen thus escaping from bodies, but it may be very easily made to enter into them. A quantity of air may be compressed into water, so as to be intimately blended with it. It finds a much easier admission into wine, or any fermented liquor; and an easier still, into spirits of wine. Some salts suck up the air in such quantities, that they are made sensibly heavier thereby, and often are melted by its moisture. In this manner, most bodies, being found either capable of receiving or affording it, we are not to be surprised at those

streams of air that are continually fleeting round the globe. Minerals, vegetables, and animals, contribute to increase the current; and are sending off their constant supplies. These, as they are differently affected by cold or heat, by mixture or putrefaction, all yield different quantities of air at different times; and the loudest tempests, and most rapid whirlwinds, are formed from their united contributions.

The sun is the principal instrument in rarefying the juices of plants, so as to give an escape to their imprisoned air; it is also equally operative in promoting the putrefaction of animals. Mineral exhalations are more frequently raised by subterranean heat. The moon, the other planets, the seasons, are all combined in producing these effects in a smaller degree. Mountains give a direction to the courses of the air. Fires carry a current of air along their body. Night and day alternately chill and warm the earth, and produce an alternate current of its vapours. These, and many other causes, may be assigned for the variety, and the activity of the winds, their continual change, and uncertain duration.

With us on land, as the wind proceeds from so many causes, and meets such a variety of obstacles, there can be but little hopes of ever bringing its motions to conform to theory; or of foretelling how it may blow a minute to come. The great Bacon, indeed, was of opinion, that by a close and regular history of the winds, continued for a number of ages together, and the particulars of each observation reduced to general maxims, we might at last come to understand the variations of

this capricious element; and that we could foretell the certainty of a wind, with as much ease as we now foretell the return of an eclipse. Indeed, his own beginnings in this arduous undertaking, seem to speak the possibility of its success; but, unhappily for mankind, this investigation is the work of ages, and we want a Bacon to direct the process.

To be able, therefore, with any plausibility, to account for the variations of the wind upon land, is not to be at present expected; and to understand any thing of their nature, we must have recourse to those places where they are more permanent and steady. This uniformity and steadiness we are chiefly to expect upon the ocean. There, where there is no variety of substances to furnish the air with various and inconstant supplies; where there are no mountains to direct the course of its current, but where all is extensively uniform and even; in such a place, the wind arising from a simple cause, must have but one simple motion. In fact, we find it so. There are many parts of the world where the winds, that with us are so uncertain, pay their stated visits. In some places they are found to blow one way by day, and another by night; in others, for one half of the year, they go in a direction contrary to their former course: but what is more extraordinary still, there are some places where the winds never change, but for ever blow the same way. This is particularly found to obtain between the tropics in the Atlantic and Æthiopic oceans; as well as in the great Pacific sea.

Few things can appear more extraordinary to a person who has never been out of our variable lati-

tudes, than this steady wind, that for ever sits in the sail, sending the vessel forward, and as effectually preventing its return. He who has been taught to consider that nothing in the world is so variable as the winds, must certainly be surprised to find a place where there is nothing more uniform. With us their inconstancy has become a proverb; with the natives of those distant climates, they may talk of a friend or a mistress as fixed and unchangeable as the winds, and mean a compliment by the comparison. When our ships are once arrived into the proper latitudes of the great Pacific ocean, the mariner forgets the helm, and his skill becomes almost useless: neither storms nor tempests are known to deform the glassy bosom of that immense sheet of waters; a gentle breeze, that for ever blows in the same direction, rests upon the canvass, and speeds the navigator. In the space of six weeks, ships are thus known to cross an immense ocean, that takes more than so many months to return. Upon returning, the trade-wind, which has been propitious, is then avoided; the mariner is generally obliged to steer into the northern latitudes, and to take the advantage of every casual wind that offers, to assist him into port. This wind, which blows with such constancy one way, is known to prevail not only in the Pacific ocean, but also in the Atlantic, between the coasts of Guinea and Brazil; and, likewise, in the Æthiopic ocean. This seems to be the great universal wind, blowing from the east to the west, that prevails in all the extensive oceans, where the land does not frequently break the general current. Were the whole surface of the globe an ocean.

there would probably be but this one wind, for ever blowing from the east, and pursuing the motions of the sun westward. All the other winds seem subordinate to this; and many of them are made from the deviations of its current. To form, therefore, any conception relative to the variations of the wind in general, it is proper to begin with that which never varies.

There have been many theories to explain this invariable motion of the winds; among the rest, we cannot omit that of Dr. Lyster, for its strangeness: "The sea," says he, "in those latitudes, is generally covered over with green weeds, for a great extent; and the air produced from the vegetable perspiration of these, produces the trade-wind." The theory of Cartesius was not quite so absurd. He alleged, that the earth went round faster than its atmosphere at the equator; so that its motion, from west to east, gave the atmosphere an imaginary one from east to west; and thus an east wind was eternally seen to prevail. Rejecting those arbitrary opinions, conceived without force, and asserted without proof, Dr. Halley has given one more plausible; which seems to be the reigning system of the day.

To conceive his opinion clearly, let us, for a moment, suppose the whole surface of the earth to be an ocean, and the air encompassing it on every side, without motion. Now, it is evident, that that part of the air which lies directly under the beams of the sun, will be rarefied; and, if the sun remained for ever in the same place, there would be a great vacuity in the air, if I may so express it, beneath the place where the sun stood. The sun

moving forward, from east to west, this vacuity will follow too, and still be made under it. But while it goes on to make new vacuities, the air will rush in to fill up those the sun has already made; in other words, as it is still travelling forward, the air will continually be rushing in behind, and pursue its motions from east to west. In this manner, the air is put into motion by day; and, by night, the parts continue to impel each other, till the next return of the sun, that gives a new force to the circulation.

In this manner is explained the constant east wind that is found blowing round the globe, near the equator. But it is also known that, as we recede from the equator on either side, we come into a trade-wind, that continually blows from the poles, from the north on one side, or the south on the other, both directing towards the equator. This also proceeds from a similar cause with the former; for the air being more rarefied in those places over which the sun more directly darts its rays, the currents will come both from the north and the south, to fill up the intermediate vacuity.

These two motions, namely, the general one from east to west, and the more particular one from both the poles, will account for all the phænomena of trade-winds; which, if the whole surface of the globe were sea, would undoubtedly be constant, and for ever continue to blow in one direction. But there are a thousand circumstances to break these air-currents into smaller ones; to drive them back against their general course; to raise or depress them; to condense them into

storms; or to whirl them in eddies. In consequence of this, regard must be often had to the nature of the soil, the position of the high mountains, the course of the rivers, and even to the luxuriance of vegetation.

If a country, lying directly under the sun, be very flat and sandy, and if the land be low and extensive, the heats occasioned by the reflection of the sun-beams, produces a very great rarefaction of the air. The deserts of Africa, which are conformable to this description, are scarcely ever fanned by a breath of wind by day; but the burning sun is continually seen blazing in intolerable splendour above them. For this reason, all along the coasts of Guinea, the wind is always perceived blowing in upon land, in order to fill up the vacuity caused by the sun's operation. In those shores, therefore, the wind blows in a contrary direction to that of its general current; and is constantly found setting in from the west.

From the same cause it happens, that those constant calms, attended with deluges of rain, are found in the same part of the ocean. For this tract being placed in the middle, between the westerly winds blowing on the coast of Guinea, and the easterly trade-winds that move at some distance from shore, in a contrary direction, the tendency of that part of the air that lies between these two opposite currents, is indifferent to either, and so rests between both in torpid serenity; and the weight of the incumbent atmosphere, being diminished by the continual contrary winds blowing from hence, it is unable to keep the vapours

suspended that are copiously borne thither; so that they fall in continual ruins.

But it is not to be supposed, that any theory can account for all the phænomena of even those winds that are known to be most regular. Instead of a complete system of the trade-winds, we must rather be content with an imperfect history. These,* as was said, being the result of a combination of effects, assume as great a variety as the causes producing them are various.

Besides the great general wind above mentioned, in those parts of the Atlantic that lie under the temperate zone, a north wind prevails constantly during the months of October, November, December, and January. These, therefore, are the most favourable months for embarking for the East Indies, in order to take the benefit of these winds, for crossing the Line: and it has been often found, by experience, that those who had set sail five months before, were not in the least farther advanced in their voyage, than those who waited for the favourable wind. During the winter of Nova Zembla, and the other arctic countries, a north wind reigns almost continually. In the Cape de Verde islands, a south wind prevails during the month of July. At the Cape of Good Hope, a north-west wind blows during the month of September. There are also regular winds, produced by various causes, upon land. The ancient Greeks were the first who observed a constant breeze, produced by the melting of the snows, in

* Buffon, vol. ii. p. 230.

some high neighbouring countries. This was perceived in Greece, Thrace, Macedonia, and the Ægean sea. The same kind of winds are now remarked in the kingdom of Congo, and the most southern parts of Africa. The flux and reflux of the sea also produces some regular winds, that serve the purposes of trade; and, in general, it may be observed, that wherever there is a strong current of water, there is a current of air that seems to attend it.

Besides these winds that are found to blow in one direction, there are, as was said before, others that blow for certain months of the year, one way, and the rest of the year the contrary way: these are called the monsoons, from a famous pilot of that name, who first used them in navigation with success.* In all that part of the ocean that lies between Africa and India, the east winds begin at the month of January, and continue till about the commencement of June. In the month of August or September, the contrary direction takes place; and the west winds prevail for three or four months. The interval between these winds, that is to say, from the end of June to the beginning of August, there is no fixed wind; but the sea is usually tossed by violent tempests, proceeding from the north. These winds are always subject to their greatest variations as they approach the land; so that, on one side of the great peninsula of India, the coasts are, for near half the year, harassed by violent hurricanes, and northern tempests; while, on the opposite side, and all along

* Varenii Geographia Generalis, cap. 20.

the coasts of Coromandel, these dreadful tempests are wholly unknown. At Java and Ceylon, a west wind begins to reign in the month of September; but, at fifteen degrees of south latitude, this wind is found to be lost, and the great general trade-wind from the east is perceived to prevail. On the contrary, at Cochin, in China, the west wind begins at March; so that these monsoons prevail, at different seasons, throughout the Indies. So that the mariner takes one part of the year to go from Java to the Moluccas; another from Cochin to Molucca; another from Molucca to China; and still another to direct him from China to Japan.

There are winds also that may be considered as peculiar to certain coasts; for example, the south wind is almost constant upon the coasts of Chili and Peru; western winds almost constantly prevail on the coast of Terra Magellanica; and in the environs of the Streights Le Maire. On the coasts of Malabar, north and north-west winds prevail continually; along the coast of Guinea, the north-west wind is also very frequent; and, at a distance from the coasts, the north-east is always found prevailing. From the beginning of November to the end of December, a west wind prevails on the coasts of Japan; and, during the whole winter, no ships can leave the port of Cochin, on account of the impetuosity of the winds that set upon the coast. These blow with such vehemence, that the ports are entirely choaked up with sand, and even boats are not able to enter. However, the east winds that prevail for the other half of the year, clear the mouths of their harbours

from the accumulations of the preceding winter, and set the confined ships at liberty. At the Straits of Babelmandel there is a south wind that periodically returns, and which is always followed by a north-east.

Besides winds thus peculiar to certain coasts, there are others found to prevail on all the coasts, in warm climates, which, during one part of the day, blow from the shore, and, during another part of it, blow from the sea. The sea-breeze, in those countries, as Dampier observes, commonly rises in the morning, about nine, proceeding slowly, in a fine small black curl, upon the surface of the water, and making its way to refresh the shore. It is gentle at first, but increases gradually till twelve, then insensibly sinks away, and is totally hushed at five. Upon its ceasing, the land-breeze begins to take its turn, which increases till twelve at night, and is succeeded, in the morning, by the sea-breeze again. Without all doubt, nothing could have been more fortunate for the inhabitants of the warm countries, where those breezes blow, than this alternate refreshment, which they feel at those seasons when it is most wanted. The heat, on some coasts, would be insupportable, were it not for such a supply of air, when the sun has rarefied all that which lay more immediately under the coast. The sea-breeze temperates the heat of the sun by day; and the land-breeze corrects the malignity of the dews and vapours by night. Where these breezes, therefore, prevail; (and they are very common,) the inhabitants enjoy a share of health and happiness, unknown to those that live much farther up the

country, or such as live in similar latitudes without this advantage. The cause of these obviously seems to arise from the rarefaction of the air by the sun, as their duration continues with its appearance, and alters when it goes down. The sun, it is observed, equally diffusing his beams upon land and sea, the land, being a more solid body than the water, receives a greater quantity of heat, and reflects it more strongly. Being thus, therefore, heated to a greater degree than the waters, it, of consequence, drives the air from land out to sea: but, its influence being removed, the air returns to fill up the former vacuity. Such is the usual method of accounting for this phænomenon; but, unfortunately, these sea and land breezes are visitants that come at all hours. On the coasts of Malabar,* the land-breezes begin at midnight, and continue till noon; then the sea-breezes take their turn, and continue till midnight. While, again, at Congo, the land-breezes begin at five, and continue till nine the next day.

But, if the cause of these be so inscrutable, that are, as we see, tolerably regular in their visitations, what shall we say to the winds of our own climate, that are continually shifting, and incapable of rest? Some general causes may be assigned, which nothing but particular experience can apply. And, in the first place, it may be observed, that clouds and heat, and, in short, whatever either increases the density or the elasticity of the air, in any one place, will produce a wind there: for the increased activity of the air thus pressing more

* Buffon, vol. ii. p. 252.

powerfully on the parts of it that are adjacent, will drive them forward; and thus go on, in a current, till the whole comes to an equality.

In this manner, as a denser air produces a wind, on the one hand; so will any accident, that contributes to lighten the air, produce it on the other: for, a lighter air may be considered as a vacuity into which the neighbouring air will rush: and hence it happens, that when the barometer marks a peculiar lightness in the air, it is no wonder that it foretells a storm.

The winds, upon large waters, are generally more regular than those upon land. The wind at sea generally blows with an even steady gale; the wind, at land, puffs by intervals, increasing its strength, and remitting it, without any apparent cause. This, in a great measure, may be owing to the many mountains, towers, or trees, that it meets in its way, all contributing either to turn it from its course, or interrupt its passage.

The east wind blows more constantly than any other, and for an obvious reason: all other winds are, in some measure, deviations from it, and partly may owe their origin thereto. It is generally, likewise, the most powerful, and for the same reason.

There are often double currents of the air. While the wind blows one way, we frequently see the clouds move another. This is generally the case before thunder; for it is well known that the thunder cloud always moves against the wind: the cause of this surprising appearance has hitherto remained a secret. From hence we may conclude, that weathercocks only inform us of that

current of the air, which is near the surface of the earth; but are often erroneous with regard to the upper regions; and, in fact, Derham has often found them erroneous.

Winds are generally more powerful on elevated situations than on the plain, because their progress is interrupted by fewer obstacles. In proportion as we ascend the heights of a mountain, the violence of the weather seems to increase, until we have got above the region of storms, where all is usually calm and serene. Sometimes, however, the storms rise even to the tops of the highest mountains; as we learn from those who have been on the Andes, and as we are convinced by the deep snows that crown even the highest.

Winds blowing from the sea are generally moister, and more attended with rains, than those which blow over extensive tracts of land: for the sea gives off more vapours to the air, and these are rolled forward upon land, by the winds blowing from thence.* For this reason, our easterly winds that blow from the continent, are dry, compared with those that blow from the surface of the ocean, with which we are surrounded on every other quarter.

In general the winds are more boisterous in spring and autumn, than at other seasons: for, that being the time of high tides, the sea may communicate a part of its motions to the winds. The sun and moon, also, which then have a greater effect upon the waters, may also have some influence upon the winds; for, there being a great

* Derham's Physico-Theol.

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body of air surrounding the globe, which, if condensed into water, would cover it to the depth of thirty-two feet, it is evident that the sun and moon will, to a proportionable degree, affect the atmosphere, and make a tide of air. This tide will be scarcely perceivable, indeed; but, without doubt, it actually exists; and may contribute to increase the vernal and autumnal storms, which are then known to prevail.

Upon narrowing the passage through which the air is driven, both the density and the swiftness of the wind is increased. For, as currents of water flow with greater force and rapidity by narrowing their channels, so also will a current of air, driven through a contracted space, grow more violent and irresistible. Hence we find those dreadful storms that prevail in the defiles of mountains, where the wind, pushing from behind through a narrow channel, at once increases in speed and density, levelling, or tearing up, every obstacle that rises to obstruct its passage.

Winds reflected from the sides of mountains and towers, are often found to be more forceful than those in direct progression. This we frequently perceive near lofty buildings, such as churches or steeples, where winds are generally known to prevail, and that much more powerful than at some distance. The air, in this case, by striking against the side of the building, acquires additional density, and, therefore, blows with more force.

These differing degrees of density, which the air is found to possess, sufficiently show that the force of the winds do not depend upon their velocity alone; so that those instruments called *anemome-*

ters, which are made to measure the velocity of the wind, will by no means give us certain information of the force of the storm. In order to estimate this with exactness, we ought to know its density; which, also, these are not calculated to discover. For this reason, we often see storms with very powerful effects, that do not seem to show any great speed; and, on the contrary, we see these wind-measurers go round, with great swiftness, when scarcely any damage has followed from the storm.

Such is the nature and the inconstancy of the irregular winds with which we are best acquainted. But their effects are much more formidable in those climates, near the tropics, where they are often found to break in upon the steady course of the trade-winds, and to mark their passage with destruction. With us the tempest is but rarely known, and its ravages are registered as an uncommon calamity; but, in the countries that lie between the tropics, and for a good space beyond them, its visits are frequent, and its effects are anticipated. In these regions the winds vary their terrors; sometimes involving all things in a suffocating heat; sometimes mixing all the elements of fire, air, earth, and water together; sometimes, with a momentary swiftness, passing over the face of the country, and destroying all things in their passage; and sometimes raising whole sandy deserts in one country, to deposit them upon some other. We have little reason, therefore, to envy these climates the luxuriance of their soil, or the brightness of their skies. Our own muddy atmosphere, that wraps us round in obscurity, though it

fails to gild our prospects with sun-shine, or our groves with fruitage, nevertheless answers the call of industry. They may boast of a plentiful, but precarious harvest; while, with us, the labourer toils in a certain expectation of a moderate, but a happy return.

In Egypt,* a kingdom so noted for its fertility, and the brightness of its atmosphere, during summer, the south winds are so hot, that they almost stop respiration; besides which, they are charged with such quantities of sand, that they sometimes darken the air, as with a thick cloud. These sands are so fine, and driven with such violence, that they penetrate every where; even into chests, be they shut never so closely. If these winds happen to continue for any length of time, they produce epidemic diseases; and are often followed by a great mortality. It is also found to rain but very seldom in that country; however, the want of showers is richly compensated by the copiousness of their dews, which greatly tend to promote vegetation.

In Persia, the winter begins in November, and continues till March. The cold, at that time, is intense enough to congeal the water; and snow falls in abundance upon their mountains. During the months of March and April, winds arise, that blow with great force, and seem to usher in the heats of summer. These return again, in autumn, with some violence; without, however, producing any dreadful effects. But, during their summer, all along the coasts of the Persian gulph, a very

* Buffon, vol. ii. p. 258.

dangerous wind prevails, which the natives call the Sameyel, still more dreadful and burning than that of Egypt, and attended with instant and fatal effects. This terrible blast, which was, perhaps, the pestilence of the ancients, instantly kills all those that it involves in its passage. What its malignity consists in, none can tell, as none have ever survived its effects, to give information. It frequently, as I am told, assumes a visible form; and darts, in a kind of bluish vapour, along the surface of the country. The natives, not only of Persia, but Arabia, talk of its effects with terror; and their poets have not failed to heighten them with the assistance of imagination. They have described it as under the conduct of a minister of vengeance, who governs its terrors, and raises, or depresses it, as he thinks proper.* These deadly winds are also known along the coasts of India, at Negapatam, Masulipatam, and Petapoli. But, luckily for mankind, the shortness of their duration diminishes the injuries that might ensue from their malignity.†

* Herbelot. Bibliothèque Oriental.

[† The pestilential winds of the East are described by various authors under various denominations. M. de Beauchamp describes a remarkable south wind in the deserts about Bagdat, called Serevansum, or poison-wind: it burns the face, impedes respiration, strips the trees of their leaves, and is said to pass on in a straight line, and often kills people in six hours. M. Volney says, the hot wind, or ramsin, seems to blow at the season when the sands of the deserts are hottest, and the air is then filled with an extremely subtile dust.

Mr. Bruce, in his Travels, thus describes the appearance and effects of the simoom. "At eleven o'clock, while we were, with great pleasure, contemplating the rugged tops of Chiggne,

The Cape of Good Hope, as well as many islands in the West Indies, are famous for their hurricanes, and that extraordinary kind of cloud which is said to produce them. This cloud, which is the fore-runner of an approaching hurricane, appears, when first seen, like a small black spot, on the verge of the horizon; and is called, by sailors, the bull's eye, from being seen so minute at a vast distance. All this time, a perfect calm reigns over the sea and land, while the cloud grows gradually broader as it approaches. At length, coming to the place where its fury is to fall, it invests the whole horizon with darkness. During all the time of its approach, a hollow murmur is heard in the cavities of the mountains; and beasts and animals, sensible of its approach, are seen running

where we expected to solace ourselves with plenty of good water, Idris cried out, with a loud voice, 'Fall on your faces, for here is the simoom.' I saw, from the S. E. a haze come, in colour like the purple part of a rainbow, but not so compressed and thick: it did not occupy twenty yards in breadth, and was about twelve feet high from the ground: it was a kind of blush upon the air, and it moved very rapidly; for I could scarce turn to fall upon the ground with my head to the northward, when I felt the heat of its current plainly upon my face. We all lay flat upon the ground as if dead, till Idris told us it was blown over. The meteor, or purple haze which I saw, was indeed passed, but the light air that blew, was of heat to threaten suffocation: for my part, I found distinctly in my breast, that I had imbibed a part of it; nor was I free of an asthmatic sensation, till I had been some months in Italy."

These winds, says Dr. Darwin, seem all to be of volcanic origin, with this difference, that the simoom is attended with a stream of electric matter: they seem to be in consequence of earthquakes, caused by the monsoon floods, which fall on volcanic fires in Syria, at the same time that they inundate the Nile.]

over the fields to seek for shelter. Nothing can be more terrible than its violence when it begins. The houses in those countries, which are made of timber, the better to resist its fury, bend to the blast like osiers, and again recover their rectitude. The sun, which, but a moment before, blazed with meridian splendour, is totally shut out; and a midnight darkness prevails, except that the air is incessantly illuminated with gleams of lightning, by which one can easily see to read. The rain falls, at the same time, in torrents; and its descent has been resembled to what pours from the spouts of our houses after a violent shower. These hurricanes are not less offensive to the sense of smelling also; and never come without leaving the most noisome stench behind them. If the seamen also lay by their wet clothes, for twenty-four hours, they are all found swarming with little white maggots, that were brought with the hurricane. Our first mariners, when they visited these regions, were ignorant of its effects, and the signs of its approach; their ships, therefore, were dashed to the bottom at the first onset; and numberless were the wrecks which the hurricane occasioned. But, at present, being forewarned of its approach, they strip their masts of all their sails, and thus patiently abide its fury. These hurricanes are common in all the tropical climates. On the coasts of Guinea they have frequently three or four in a day, that thus shut out the heavens, for a little space; and when past, leave all again in former splendour. They chiefly prevail on that coast in the intervals of the trade-winds; the ap-

proach of which clears the air of its meteors, and gives these mortal showers that little degree of wholesomeness which they possess. They chiefly obtain there during the months of April and May; they are known at Loango from January to April; on the opposite coast of Africa, the hurricane season begins in May; and, in general, whenever a trade-wind begins to cease, these irregular tempests are found to exert their fury.

All this is terrible; but there is a tempest, known in those climates, more formidable than any we have hitherto been describing, which is called, by the Spaniards, a Tornado. As the former was seen arriving from one part of the heavens, and making a line of destruction; so the winds in this seem to blow from every quarter, and settle upon one destined place, with such fury, that nothing can resist their vehemence. When they have all met in their central spot, then the whirlwind begins with circular rapidity. The sphere every moment widens as it continues to turn, and catches every object that lies within its attraction. This also, like the former, is preceded by a flattering calm; the air is every where hushed; and the sea is as smooth as polished glass: however, as its effects are more dreadful than those of the ordinary hurricane, the mariner tries all the power of his skill to avoid it; which, if he fails of doing, there is the greatest danger of his going to the bottom. All along the coasts of Guinea, beginning about two degrees north of the line, and so downward, lengthwise, for about a thousand miles, and as many broad, the ocean is unnavigable on account of these tornadoes. In

this torrid region there reign unceasing tornadoes, or continual calms; among which, whatever ship is so unhappy as to fall, is totally deprived of all power of escaping. In this dreadful repose of all the elements, the solitary vessel is obliged to continue, without a single breeze to assist the mariner's wishes, except those whirlwinds, which only serve to increase his calamity. At present, therefore, this part of the ocean is totally avoided; and, although there may be much gold along the coasts of that part of Africa, to tempt avarice, yet there is something, much more dreadful than the fabled dragon of antiquity, to guard the treasure. As the internal parts of that country are totally unknown to travellers, from their burning sands and extensive deserts, so here we find a vast tract of ocean, lying off in shores, equally unvisited by the mariner.

But of all these terrible tempests that deform the face of Nature, and repress human presumption, the sandy tempests of Arabia and Africa are the most terrible, and strike the imagination most strongly. To conceive a proper idea of these, we are by no means to suppose them resembling those whirlwinds of dust that we sometimes see scattering in our air, and sprinkling their contents upon our roads or meadows. The sand-storm of Africa exhibits a very different appearance. As the sand of which the whirlwind is composed is excessively fine, and almost resembles the parts of water, its motion entirely resembles that of a fluid; and the whole plain seems to float onward, like a slow inundation. The body of sand thus rolling, is deep enough to bury houses and palaces in its bosom: travellers,

who are crossing those extensive deserts, perceive its approach at a distance; and, in general, have time to avoid it, or turn out of its way, as it generally extends but to a moderate breadth. However, when it is extremely rapid, or very extensive, as sometimes is the case, no swiftness, no art, can avail; nothing then remains, but to meet death with fortitude, and submit to be buried alive with resignation.

It is happy for us of Britain, that we have no such calamity to fear; for, from this, even some parts of Europe are not entirely free. We have an account given us, in the History of the French Academy, of a miserable town in France, that is constantly in danger of being buried under a similar inundation; with which I will take leave to close this chapter. "In the neighbourhood of St. Paul de Leon, in Lower Brittany,* there lies a tract of country along the sea-side, which before the year 1666 was inhabited, but now lies deserted, by reason of the sands which cover it, to the height of twenty feet; and which every year advance more and more inland, and gain ground continually. From the time mentioned above, the sand has buried more than six leagues of the country inward; and it is now but half a league from the town of St. Paul; so that, in all appearance, the inhabitants must be obliged to abandon it entirely. In the country that has been overwhelmed, there are still to be seen the tops of some steeples peeping through the sand, and many chimnies that still remain above the sandy ocean. The inhabitants,

* Histoire de l'Académie des Sciences, an. 1722.

however, had sufficient time to escape; but being deprived of their little all, they had no other resource but begging for their subsistence. This calamity chiefly owes its advancement to a north, or an east wind, raising the sand, which is extremely fine, in such great quantities, and with such velocity, that M. Deslandes, who gave the account, says, that while he was walking near the place, during a moderate breeze of wind, he was obliged, from time to time, to shake the sand from his clothes and his hat, on which it was lodged in great quantities, and made them too heavy to be easily borne. Still further, when the wind was violent, it drove the sand across a little arm of the sea, into the town of Roscoff, and covered the streets of that place two feet deep; so that they have been obliged to carry it off in carts. It may also be observed, that there are several particles of iron mixed with the sand, which are readily affected by the loadstone. The part of the coast that furnishes these sands, is a tract of about four leagues in length; and is upon a level with the sea at high-water. The shore lies in such a manner as to leave its sands, subject only to the north and east winds, that bear them farther up the shore. It is easy to conceive how the same sand that has at one time been borne a short way inland, may, by some succeeding and stronger blast, be carried up much higher; and thus the whole may continue advancing forward, deluging the plain, and totally destroying its fertility. At the same time, the sea, from whence this deluge of sand proceeds, may furnish it in inexhaustible quantities. This unhappy country, thus overwhelmed in so singular a manner, may

well justify what the ancients and the moderns have reported concerning those tempests of sand in Africa, that are said to destroy villages, and even armies in their bosom."

[Dr. Darwin observes, "the air is perpetually subject to increase or diminution from its combination with other bodies, or its evolution from them. The vital part of the air, called oxygene, is continually produced in this climate from the perspiration of vegetables in the sun-shine, and probably from the action of light on clouds or on water in the tropical climates, where the sun has greater power, and can exert some yet unknown laws of luminous combination. Another part of the atmosphere, which is called azote, is perpetually set at liberty from animal and vegetable bodies by putrefaction or combustion, from many springs of water, from volatile alkali, and probably from fixed alkali; of which there is an inexhaustible source in the water of the ocean. Both these component parts of the air are perpetually again diminished by their contact with the soil which covers the surface of the earth, producing nitre. The oxygene is diminished in the production of all acids, of which the carbonic and muriatic exist in great abundance: the azote is diminished in the growth of animal bodies, of which it constitutes an important part, and in its combinations with many other natural productions."

They are both probably diminished in immense quantities by uniting with the inflammable air which arises from the mud and rivers of lakes at some seasons, when the atmosphere is light, the oxygene of the air producing water, and the azote

producing volatile alkali by their combinations with this inflammable air. At other seasons of the year these principles may again change their combinations, and the atmospheric air be re-produced.

M. Lavoisier found that one pound of charcoal in burning consumed two pounds nine ounces of vital air, or oxygene. In the process of making red lead, every barrel containing 1,200 weight, contains nearly 2,000 cubic feet of vital air. If this can be performed in miniature, what may not be done in the immense elaboratories of Nature?

Air is likewise manufactured and destroyed in the greatest abundance within the polar circles. Can this be effected by some yet unknown law of the congelation of aqueous or saline fluids, which may set at liberty their combined heat, and convert both a part of the acid and alkali of sea-water into their component airs? Or, on the contrary, can the electricity of the northern lights convert inflammable air and oxygene into water; whilst the great degree of heat at the poles, unites the azote with some other base? Another manufacture of air would seem to exist within the tropics, or at the line, though in a much less quantity than at the poles, owing, perhaps, to the action of the sun's light on the moisture suspended in the air: but in all other parts of the earth these absorptions and evolutions of air, in a greater or less degree, are perpetually going on in inconceivable abundance; increased probably, and diminished at different seasons of the year, by the approach or retrocession of the sun's light. To this should be added, that as heat and electricity, and perhaps magnetism, are known to displace air, it is not impossible but that

the increased or diminished quantities of these fluids diffused in the atmosphere may increase its weight as well as its bulk.

South-west Winds. The velocity of the surface of the earth, in moving round its axis, diminishes from the equator to the poles: whence if a region of air in this country should be suddenly removed a few degrees towards the north, it must constitute a western wind. South-west winds, therefore, consist of air flowing from the south, and seeming occasionally absorbed on its arrival at more northern latitudes. It has a real direction from the west, owing to its not having lost on its journey the greater velocity it had acquired from the earth's surface from whence it came. These winds are analogous to the monsoons between the tropics, and frequently continue for four or six weeks together, with a low barometer and rainy weather. 2. They sometimes consist of north-east air, which had passed by us or over us, which becomes retrograde by a commencing deficiency of the air of the north. These winds continue but a day or two, attended with a severe frost with a sinking barometer; their cold being increased by their expansion, as they return into an incipient vacancy.

North-east Winds consist of air flowing from the north, where it seems occasionally produced: has an apparent direction from the east, owing to its not having acquired in its journey the increasing velocity of the earth's surface; these winds are analogous to the trade winds between the tropics, and frequently continue in the vernal months for four and six weeks together, with a

high barometer, and fair or frosty weather. 2. They sometimes consist of south-west air, which had passed by us or over us, driven back by a new accumulation of air in the north: these continue but a day or two, and are attended with rain.

North-west Winds consist, first of south-west winds which have passed over us, bent down and driven back towards the south by newly generated northern air: they continue but a day or two, and are attended with rain or clouds. 2. They consist of north-east winds bent down from the higher parts of the atmosphere; and having there acquired greater velocity than the earth's surface, are frosty or fair. 3. They consist of north-east winds formed into a vertical or spiral eddy, as on the eastern coasts of North America, and bring severe frost.

South-east Winds consist, first of north-east winds, become retrograde, continued for a day or two, frosty or fair, with a sinking barometer. 2. They consist of north-east winds formed into a vertical eddy, not a spiral one, frosty or fair.

North Winds consist, first of air flowing slowly from the north, so that they acquire the velocity of the earth's surface as they approach; they are fair or frosty, and seldom occur. 2. They consist of retrograde south winds; these continue but a day or two, are preceded by south-west winds, and are generally succeeded by north-east winds, cloudy or rainy, with the barometer rising.

South Winds consist, first of air flowing slowly from the south, losing their previous western velocity by the friction of the earth's surface as they approach; they are moist, and seldom occur.

2. They consist of retrograde north winds: these continue but a day or two, are preceded by north-east winds, and generally succeeded by south-west winds: they are colder, with the barometer sinking.

East Winds consist of air brought hastily from the north, and not impelled farther forwards, owing to a sudden beginning absorption of air, in the northern regions; they are very cold, with the barometer high, and generally succeeded by south-west winds.

West Winds consist of air brought hastily from the south, and checked from proceeding farther to the north by a beginning production of air from the northern regions: they are warm and moist, and generally succeeded by north-east winds. 2. They consist of air bent down from the higher regions of the atmosphere: if this air be from the south, and brought hastily, it becomes a wind of great velocity, moving perhaps sixty miles in an hour: it is warm and rainy, and if it consists of northern air bent down, it is of less velocity and colder.

Trade Winds. A column of heated air becomes lighter than before, and will therefore ascend, by the pressure of the cold air which surrounds it, like a cork in water, or like heated smoke in a chimney. Now as the sun passes twice over the equator, for once over the tropic, the equator has not time to become cool, and on this account it is generally hotter at the line than at the tropics; and therefore the air over the line, except in some few instances hereafter to be mentioned, continues to ascend at all seasons of the year, pressed upwards by regions of air brought from the tropics. This

air thus brought from the tropics to the equator, and which had previously only acquired the velocity of the earth's surface at the tropics, will now move too slow for the earth's surface at the equator, and will thence appear to move in a direction contrary to the motion of the earth: hence the trade-winds, though they consist of regions of air brought from the north on one side of the line, and from the south on the other, will appear to have the diagonal direction of north-east and south-west winds. Now it is commonly believed, that there are superior currents of air passing over these north-east and south-east currents in a contrary direction, and which descending near the tropics produce vertical whirlpools of air. The moisture contained or dissolved in the ascending heated air at the line, must exist in great tenuity, and by being exposed to the great light of the sun in that climate, the water may be decomposed, and the new airs spread on the atmosphere from the line to the poles.

Monsoons and *tornadoes* in the Arabian and Indian seas, are winds which blow six months one way, and six months the other, and are called monsoons; by the accidental disposition of land and sea it happens, that, in some places, the air near the tropic is supposed to become warmer when the sun is vertical over it, than at the line. The air in these places consequently ascends, pressed upon one side by the north-east regions of air, and on the other side by the south-west regions of air: for as the air brought from the south has previously obtained the velocity of the earth's surface at the line, it moves faster than the earth's surface near the tropic where it now arrives, and becomes a south-

west wind; while the air from the north becomes a north-east wind. These two winds do not so quietly join and ascend as the north-east and south-east winds, which meet at the line with equal warmth and velocity, and form the trade-winds; but as they meet in contrary directions before they ascend, and cannot be supposed accurately to balance each other, a rotatory motion will be produced as they ascend, like water falling through a hole, and a horizontal or spiral eddy is the consequence: these eddies are more or less rapid, and are called tornadoes in their most violent state, raising water from the ocean in the west, or sand from the deserts in the east; in less violent degrees they only mix the two currents of north-east and south-west air, and produce by this means incessant rains, as the air of the north-west acquires some of the heat of the south-west wind. This circumstance of the eddies of air and sand produced by the monsoon winds in Abyssinia is thus described by Mr. Bruce. "We were here at once surprised and terrified by a sight surely one of the most magnificent in the world. In that vast expanse of desert from west and to north-west of us, we saw a number of prodigious pillars of sand at different distances, at times moving with great celerity, at others stalking on with a majestic slowness; at intervals we thought they were coming in a very few minutes to overwhelm us; and small quantities of sand did, more than once, actually reach us. Again they would retreat so as to be almost out of sight, their tops reaching to the very clouds: there the tops often separated from the bodies; and these, once disjointed, dispersed in the air, and did not appear more. Sometimes they

were broken near the middle, as if struck with a large cannon-shot. About noon, they began to advance with considerable swiftness upon us, the wind being very strong at north. Eleven of them ranged along-side of us about the distance of three miles. The greatest diameter of the largest appeared to me, at that distance, as if it would measure ten feet: they retired from us with a wind at south-east, leaving an impression on my mind to which I can give no name, though surely one ingredient in it was fear, with a considerable deal of wonder and astonishment. It was in vain to think of flying: the swiftest horse, or fastest-sailing ship could be of no use to carry us out of this danger; and the full persuasion of this, rivetted me as if to the spot where I stood, and I let the camels gain on me so much in my state of lameness, that it was with some difficulty I could overtake them." He likewise relates that, for many successive mornings, at the commencement of the rainy monsoon, he observed a cloud of apparently small dimension whirling round with great rapidity, and, in a few minutes, the heavens became covered with dark clouds and consequent great rains.

Another cause of tornadoes, independent of the monsoons, is ingeniously explained by Dr. Franklin. When, in the tropical countries, a stratum of inferior air becomes so heated by its contact with the warm earth, that its expansion is increased more than is equivalent to the pressure of the stratum of air over it; or when the superior stratum becomes more condensedly cold than the inferior one by pressure, the upper region will descend and the lower ascend: in this situation, if one part of

the atmosphere be hotter from some fortuitous circumstances, or has less pressure over it, the lower stratum will begin to ascend at this part, and resemble water passing through a hole, as mentioned above. If the lower region of air was going forwards with considerable velocity, it will gain an eddy by rising up this hole in the incumbent heavy air, so that the whirlpool or tornado has not only its progressive velocity, but its circular one also, which thus lifts up or overturns every thing within its spiral whirl. By the weaker whirlwinds in this country, the trees are sometimes thrown down in a line of only twenty or forty yards in breadth, making a kind of avenue through a country. In the West Indies the sea rises like a cone in the whirl, and is met by black clouds produced by the cold upper air, and the warm lower air being rapidly mixed; whence are produced the great and sudden rains called water-spouts, while the upper and lower airs exchange their plus or minus electricity in perpetual lightnings.

Land and Sea Breezes. The sea being a transparent mass, is less heated at its surface by the sun's rays than the land, and its continual change of surface contributes to preserve a greater uniformity in the heat of the air which hangs over it: hence the surface of the tropical islands is more heated during the day than the sea that surrounds them, and cools more in the night, by its greater elevation; whence, in the afternoon, when the lands of the tropical islands have been much heated by the sun, the air over them ascends pressed upwards by the cooler air of the encircling ocean; in the morning again the land becoming

cooled more than the sea, the air over it descends by its increased gravity, and blows over the ocean near its shores.]

CHAP. XXI.

Of Meteors, and such Appearances as result from a Combination of the Elements.

IN proportion as the substances of nature are more compounded and combined, their appearances become more inexplicable and amazing. The properties of water have been very nearly ascertained. Many of the qualities of air, earth, and fire, have been discovered and estimated; but when these come to be united by Nature, they often produce a result which no artificial combinations can imitate: and we stand surprised, that although we are possessed of all those substances which Nature makes use of, she shows herself a much more various operator than the most skilful chemist ever appeared to be. Every cloud that moves, and every shower that falls, serves to mortify the philosopher's pride, and to show him hidden qualities in air and water, that he finds it difficult to explain. Dews, hail, snow, and thunder, are not less difficult for being more common. Indeed, when we reflect on the manner in which Nature performs any one of these operations, our wonder increases. To see water, which is heavier than air, rising in air, and then falling in a form so very different from that in which it rose; to see the same fluid at one time descending in the form of

hail, at another in that of snow; to see two clouds, by dashing against each other, producing an electrical fire, which no watery composition that we know of can effect; these, I say, serve sufficiently to excite our wonder; and still the more, in proportion as the objects are ever pressing on our curiosity. Much, however, has been written concerning the manner in which Nature operates in these productions; as nothing is so ungrateful to mankind as hopeless ignorance.

And first, with regard to the manner in which water evaporates, and rises to form clouds, much has been advanced, and many theories devised. All water,* say some, has a quantity of air mixed with it; and the heat of the sun darting down, disengages the particles of this air from the grosser fluid: the sun's rays being reflected back from the water, carry back with them those bubbles of air and water which, being lighter than the condensed air, will ascend till they meet with a more rarefied air; and they will then stand suspended. Experience, however, proves nothing of all this. Particles of air or fire are not thus known to ascend with a thin coat of water; and, in fact, we know that the little particles of steam are solid drops of water. But, besides this, water is known to evaporate more powerfully in the severest frost, than when the air is moderately warm.† Doctor Hamilton, therefore, of the university of Dublin, rejecting this theory, has endeavoured to establish another. According to him,

* Spectacle de la Nature, vol. iii.

† Mémoires de l'Académie des Sciences, an. 1705.

as aqua-fortis is a menstruum that dissolves iron, and keeps it mixed in the fluid; as aqua-regia is a menstruum that dissolves gold; or as water dissolves salts to a certain quantity; so air is a menstruum that corrodes and dissolves a certain quantity of water, and keeps it suspended above. But, however ingenious this may be, it can hardly be admitted; as we know, by Mariotte's experiment,* that if water and air be inclosed together, instead of the air's acting as a menstruum upon the water, the water will act as a menstruum upon the air, and take it all up. We know also, that of two bodies, that which is most fluid and penetrating, is most likely to be the menstruum of the other; but water is more fluid and penetrating than air, and, therefore, the most likely of the two to be the menstruum. We know that all bodies are more speedily acted upon, the more their parts are brought into contact with the menstruum that dissolves them: but water, inclosed with comprest air, is not the more diminished thereby.† In short, we know, that cold, which diminishes the force of other menstruums, is often found to promote evaporation. In this variety of opinion, and uncertainty of conjecture, I cannot avoid thinking that a theory of evaporation may be formed upon very simple and obvious principles, and embarrassed, as far as I can conceive, with very few objections.

We know that a repelling power prevails in nature, not less than an attractive one. This repul-

* Mariotte, de la Nature de l'Air, p. 97, 106.

† See Boyle's Works, vol. ii. p. 619.

sion prevails strongly between the body of fire and that of water. If I plunge the end of a red hot bar of iron into a vessel of water, the fluid rises, and large drops of it fly up in all manner of directions, every part bubbling and steaming until the iron be cold. Why may we not, for a moment, compare the rays of the sun, darted directly upon the surface of the water, to so many bars of red-hot iron; each bar, indeed, infinitely small, but not the less powerful? In this case, wherever a ray of fire darts, the water, from its repulsive quality, will be driven on all sides; and, of consequence, as in the case of the bar of iron, a part of it will rise. The parts thus rising, however, will be extremely small; as the ray that darts is extremely so. The assemblage of the rays darting upon the water in this manner, will cause it to rise in a light thin steam above the surface; and, as the parts of this steam are extremely minute, they will be lighter than air, and, consequently, float upon it. There is no need for supposing them bubbles of water filled with fire; for any substance, even gold itself, will float on air, if its parts be made small enough; or, in other words, if its surface be sufficiently increased. This water, thus disengaged from the general mass, will be still farther attenuated and broken by the reflected rays, and consequently more adapted for ascending.

From this plain account, every appearance in evaporation may be easily deduced. The quantity of heat increases evaporation, because it raises a greater quantity of steam. The quantity of wind increases evaporation; for, by waving the surface

of the water, it thus exposes a greater surface to the evaporating rays. A dry frost, in some measure, assists the quantity of evaporation; as the quantity of rays are found to be no way diminished thereby. Moist weather alone prevents evaporation; for the rays being absorbed, refracted, and broken, by the intervening moisture, before they arrive at the surface, cannot produce the effect; and the vapour will rise in a small proportion.

Thus far we have accounted for the ascent of vapours; but to account for their falling again, is attended with rather more difficulty. We have already observed, that the particles of vapour, disengaged from the surface of the water, will be broken and attenuated in their ascent, by the reflected, and even the direct rays, that happen to strike upon their minute surfaces. They will, therefore, continue to ascend, till they rise above the operation of the reflected rays, which reaches but to a certain height above the surface of the earth. Being arrived at this region, which is cold for want of reflected heat, they will be condensed, and suspended in the form of clouds. Some vapours, that ascend to great heights, will be frozen into snow; others, that are condensed lower down, will put on the appearance of a mist, which we find the clouds to be when we ascend among them, as they hang along the sides of a mountain. These clouds of snow and rain, being blown about by winds, are either entirely scattered and dispersed above, or they are still more condensed by motion, like a snow-ball, that grows more large and solid as it continues to roll. At last, therefore, they will become too weighty for the air

which first raised them to sustain; and they will descend, with their excess of weight, either in snow or rain. But, as they will fall precipitately when they begin to descend, the air, in some measure, will resist the falling; for, as the descending fluid gathers velocity in its precipitation, the air will increase its resistance to it, and the water will, therefore, be thus broken into rain; as we see, that water which falls from the tops of houses, though it begins in a spout, separates into drops before it has got to the bottom. Were it not for this happy interposition of the air, between us and the water falling from a considerable height above us, a drop of rain might fall with dangerous force, and a hail-stone might strike us with fatal rapidity.

In this manner, evaporation is produced by day; but when the sun goes down, a part of that vapour which his rays had excited, being no longer broken, and attenuated by the reflecting rays, it will become heavier than the air, even before it has reached the clouds; and it will, therefore, fall back in dews, which differ only from rain in descending before they have had time to condense into a visible form.*

[* According to Dr. Darwin, the atmosphere will dissolve a certain quantity of moisture as a chemical menstruum, even when it is much below the freezing point, as appears from the diminution of ice suspended in frosty air; but a much greater quantity of water is evaporated and suspended in the air by means of heat, which is, perhaps, the universal cause of fluidity, for water is known to boil with less heat in vacuo, and that the air, therefore, rather hinders than promotes its evaporation in higher degrees of heat. The quick evaporation occasioned in vacuo by a small degree of heat is agreeably seen in what is

Hail, the Cartesians say, is a frozen cloud, half melted and frozen again in its descent. A hoar

termed a pulse-glass, which consists of an exhausted tube of glass, with a bulb at each end of it, and with about two-thirds of the cavity filled with alkohol, in which the spirit is instantly seen to boil by the heat of the finger's end applied on a bubble of steam in the lower bulb, and is condensed again in the upper bulb by the least conceivable comparative coldness.

Another circumstance evincing that heat is the principal cause of evaporation is, that at the time of water being converted into steam, a great quantity of heat is taken away from the neighbouring bodies: if a thermometer be repeatedly dipped in ether or in rectified spirits of wine, and exposed to a blast of air to expedite the evaporation by removing the saturated air from it, the thermometer will presently sink below freezing. This warmth taken from the ambient bodies at the time of evaporation by the steam, is again given out when the steam is condensed into water: hence the water in a worm-tub during distillation so soon becomes hot, and hence the warmth accompanying the descent of rain in cold weather. Hence water may either be dissolved in air, and may then be called an aërial solution of water; or it may be dissolved in the fluid matter of heat, according to the theory of M. Lavoisier, and may then be called steam.

But, as water is, perhaps, many hundred times more soluble in the fluid matter of heat than in air, the eduction of this heat, by whatever means it is occasioned, may be the principal cause of evaporation. Thus if a region of air is brought from a warmer climate, as the south-west winds, it becomes cool by its contact with the earth in this latitude, and parts with so much of its moisture as was dissolved in the quantity of heat, which it now loses, but retains that part which was suspended by its attraction to the particles of air, or by aërial solution, even in the most severe frosts. A second immediate cause of rain, is a stream of N. E. wind descending from a superior current of air, and mixing with the warmer S. W. wind below; or the reverse of this (viz.) a superior current of S. W. wind mixing with an inferior one of N. E. wind: in both these cases the whole heavens become instantly clouded, and the moisture contained in

frost is but a frozen dew. Lightning we know to be an electrical flash, produced by the opposition

the S.W. current is precipitated. A third method by which a region of air becomes cooled, and in consequence deposits much of its moisture, is from the mechanical expansion of air when part of the pressure is taken off: in this case the expanded air becomes capable of receiving or attracting some of the matter of heat into its interstices, and the vapour, which was previously dissolved in this heat, is deposited, as is seen in the receiver of an air-pump, which becomes dewy, as the air within becomes expanded by the eduction of part of it. Another portion of atmospheric water may possibly be held in solution by the electric fluid, since, in thunder-storms, a precipitation of the water seems to be either the cause or the consequence of the eduction of the electricity; but it appears more probable, that the water is condensed into clouds by the eduction of its heat, and that then the surplus of electricity prevents their coalescence into larger drops, which immediately succeeds the departure of lightning.

The immediate cause why the barometer sinks before rain is, first, because a region of warm air, brought to us in the place of the cold air which it had displaced, must weigh lighter, both specifically and absolutely, if the height of the warm atmosphere be supposed to be equal to that of the preceding cold one: and, secondly, after the drops of rain begin to fall in any column of air, that column becomes lighter, the falling drops only adding to the pressure of air in proportion to the resistance which they meet with in passing through that fluid.

If we could suppose water to be dissolved in air without heat, or in very low degrees of heat, the air would probably become heavier, as happens in many chemical solutions; but if water dissolved in the matter of heat, be mixed with an aërial solution of water, there can be no doubt but an atmosphere consisting of such a mixture must become lighter in proportion to the quantity of the matter of heat. On the same circumstance depends the visible vapour produced from the breath of animals in cold weather, or from boiling a kettle; the particles of cold air with which it is mixed, steal a part of its heat, and become themselves raised in temperature; whence part of the water is

of two clouds: and thunder to be the sound proceeding from the same, continued by an echo reverberated among them. It would be to very little purpose, to attempt explaining exactly how these wonders are effected: we have as yet but little insight into the manner in which these meteors are found to operate upon each other; and, therefore, we must be contented with a detail rather of their effects than their causes.*

precipitated in visible vapour, which, if in great quantity, sinks to the ground, if in small quantity, and the surrounding air be not previously saturated, spreads itself till it becomes again dissolved.]

[* The atmosphere, having been shown to consist of certain proportions of vital and foul air, together with a mixture of other gases; the changes which take place show that new combinations and decompositions are continually going on in it: on these chemical alterations depend the greater number of meteorological phenomena, and they may be considered as the result of the mutual action of the different component parts of the atmosphere, aided by electricity. Rain, besides its being caused by the compression of evaporated moisture, may be produced by the mixture of hydrogene in certain proportions with the common atmospheric air: for, when two parts of hydrogene gas are mixed with six parts of common air, the mixture explodes with a great noise and violence, and a quantity of water is formed equal in weight to these two bodies. This may account for violent thunder-storms, accompanied with lightning and loud peals of thunder. Snow and hail appear to be aggregate particles of vapour becoming too heavy for suspension in the atmosphere, and congealed or frozen by passing through a stream of cold air: shooting stars consist of electric sparks, or lightning, passing from one part to another in the higher regions of the atmosphere. Lightning is produced in the lower region of air, from the accumulation or defect of electric matter in those floating fields of vapour: and, as it is thus produced in dense air, it proceeds but a short course; on account of the greater resistance it meets, and is attended with a loud explosion. Meteors, or fire-balls, Dr.

In our own gentle climate, where Nature wears the mildest and kindest aspect, every meteor seems to befriend us. With us, rains fall in refreshing showers, to enliven our fields, and to paint the landscape with a more vivid beauty. Snows cover the earth, to preserve its tender vegetables from the inclemency of the departing winter. The dews descend with such an imperceptible fall as no way injures the constitution. Even thunder is seldom injurious; and it is often wished for by the husbandman, to clear the air, and to kill numberless insects that are noxious to vegetation. Hail is the most injurious meteor that is known in our climate; but it seldom visits us with violence, and then its fury is but transient.

One of the most dreadful storms we hear of,*

Darwin supposes, may be produced in the second region of air, where the twilight ceases to be refracted, where the air is 3,000 times rarer than at the surface of the earth, and where the common air is surrounded by an atmosphere of inflammable gas tenfold rarer than itself: in this region, in which a ball of electricity might pass with infinite ease and velocity, such a ball passing between inflammable and common air, would set fire to them as it passed along. On the 18th of August, 1783, one of these large meteors or fire-balls appeared, which was estimated to be between 60 and 70 miles high, and to travel 1,000 miles, at the rate of about 20 miles a second: it had a real train of light left behind it in its passage; and in some part of its course gave off sparks or explosions. Northern lights seem to be electric streams, taking place in the same region of the atmosphere, where the common air exists in extreme tenuity, and where they seem to be repelled or radiated from an accumulation of that fluid in the north, and not attracted like fire-balls: this may account for the diffusion of their light, as well as the silence of their passage.]

* Phil. Trans. vol. ii. p. 147.

was that of Hertfordshire, in the year 1697. It began by thunder and lightning, which continued for some hours, when suddenly a black cloud came forward, against the wind, and marked its passage with devastation. The hail-stones which it poured down, being measured, were found to be many of them fourteen inches round, and, consequently, as large as a bowling-green ball. Wherever it came, every plantation fell before it; it tore up the ground, split great oaks, and other trees, without number; the fields of rye were cut down, as if levelled with a scythe; wheat, oats, and barley, suffered the same damage. The inhabitants found but a precarious shelter, even in their houses, their tiles and windows being broke by the violence of the hail-stones, which, by the force with which they came, seemed to have descended from a great height. The birds, in this universal wreck, vainly tried to escape by flight; pigeons, crows, rooks, and many more of the smaller and feebler kinds, were brought down. An unhappy young man, who had not time to take shelter, was killed; one of his eyes was struck out of his head, and his body was all over black with the bruises: another had just time to escape, but not without the most imminent danger, his body being bruised all over. But what is most extraordinary, all this fell within the compass of a mile.

Mezeray, in his History of France, tells us of a shower of hail much more terrible, which happened in the year 1510, when the French monarch invaded Italy. There was, for a time, a horrid darkness, thicker than that of midnight, which continued till the terrors of mankind were changed to still more terrible objects, by thunder and lightning breaking

the gloom, and bringing on such a shower of hail, as no history of human calamities could equal. These hail-stones were of a bluish colour; and some of them weighed not less than a hundred pounds. A noisome vapour of sulphur attended the storm. All the birds and beasts of the country were entirely destroyed. Numbers of the human race suffered the same fate. But what is still more extraordinary, the fishes found no protection from their native element, but were equal sufferers in the general calamity.

These, however, are terrors that are seldom exerted in our mild climates. They only serve to mark the page of history with wonder; and stand as admonitions to mankind, of the various stores of punishment in the hands of the Deity, which his power can treasure up, and his mercy can suspend.

In the temperate zones, therefore, meteors are rarely found thus terrible: but between the tropics, and near the poles, they assume very dreadful and various appearances. In those inclement regions, where cold and heat exert their chief power, meteors seem peculiarly to have fixed their residence. They are seen there in a thousand terrifying forms, astonishing to Europeans, yet disregarded by the natives, from their frequency. The wonders of air, fire, and water, are there combined, to produce the most tremendous effects; and to sport with the labours and apprehensions of mankind. Lightnings, that flash without noise; hurricanes, that tear up the earth; clouds, that all at once pour down their contents, and produce an instant deluge; mock suns, northern lights, that illuminate half the hemi-

sphere; circular rainbows; halos; fleeting balls of fire; clouds, reflecting back the images of things on earth, like mirrors; and water-spouts, that burst from the sea, to join with the mists that hang immediately above them—These are but a part of the phænomena that are common in those countries; and from many of which, our own climate is, in a great measure, exempted.

The meteors of the torrid zone are different from those that are found near the polar circles: and it may readily be supposed, that in those countries where the sun exerts the greatest force in raising vapours of all kinds, there should be the greatest quantity of meteors. Upon the approach of the winter months, as they are called, under the line, which usually begin about May, the sky, from a fiery brightness, begins to be overcast, and the whole horizon seems wrapt in a muddy cloud. Mists and vapours still continue to rise; and the air, which so lately before was clear and elastic, now becomes humid, obscure, and stifling: the fogs become so thick, that the light of the sun seems, in a manner, excluded; nor would its presence be known, but for the intense and suffocating heat of its beams, which dart through the gloom, and, instead of dissipating, only serve to increase the mist. After this preparation, there follows an almost continual succession of thunder, rain, and tempests. During this dreadful season, the streets of cities flow like rivers; and the whole country wears the appearance of an ocean. The inhabitants often make use of this opportunity to lay in a stock of fresh water, for the rest of the year; as the same cause which pours down the deluge at one season,

denies the kindly shower at another. The thunder which attends the fall of these rains, is much more terrible than that we are generally acquainted with. With us the flash is seen at some distance, and the noise shortly after ensues; our thunder generally rolls on one quarter of the sky, and one stroke pursues another. But here it is otherwise; the whole sky seems illuminated with unremitted flashes of lightning; every part of the air seems productive of its own thunders; and every cloud produces its own shock. The strokes come so thick, that the inhabitants can scarce mark the intervals; but all is one unremitted roar of elementary confusion. It should seem, however, that the lightning of those countries is not so fatal, or so dangerous, as with us; since, in this case, the torrid zone would be uninhabitable.

When these terrors have ceased, with which, however, the natives are familiar, meteors of another kind begin to make their appearance. The intense beams of the sun, darting upon stagnant waters, that generally cover the surface of the country, raise vapours of various kinds. Floating bodies of fire, which assume different names, rather from their accidental forms, than from any real difference between them, are seen without surprise. The draco volans, or flying dragon, as it is called; the ignis fatuus, or wandering fire; the fires of St. Helmo, or the mariner's light, are every where frequent: and of these we have numberless descriptions. "As I was riding in Jamaica," says Mr. Barbham, "one morning from my habitation, situated about three miles north-west from Jago de la Vega, I saw a ball of fire, appearing to me of the

bigness of a bomb, swiftly falling down with a great blaze. At first I thought it fell into the town; but when I came nearer, I saw many people gathered together, a little to the southward in the Savannah, to whom I rode up, to inquire the cause of their meeting: they were admiring, as I found, the ground's being strangely broke up and ploughed by a ball of fire; which, as they said, fell down there. I observed there were many holes in the ground; one in the middle, of the bigness of a man's head, and five or six smaller round about it, of the bigness of one's fist, and so deep as not to be fathomed by such implements as were at hand. It was observed, also, that all the green herbage was burnt up, near the holes; and there continued a strong smell of sulphur near the place, for some time after."

Ulloa gives an account of one of a similar kind, at Quito.* "About nine at night," says he, "a globe of fire appeared to rise from the side of the mountain Pichinca, and so large, that it spread a light over all the part of the city facing that mountain. The house where I lodged looking that way, I was surprised with an extraordinary light, darting through the crevices of the window-shutters. On this appearance, and the bustle of the people in the street, I hastened to the window, and came time enough to see it, in the middle of its career; which continued from west to south, till I lost sight of it, being intercepted by a mountain, that lay between me and it. It was round; and its apparent diameter about a foot. I observed it to rise from

* Ulloa, vol. i. p. 41.

the sides of Pichinca; although, to judge from its course, it was behind that mountain where this congeries of inflammable matter was kindled. In the first half of its visible course, it emitted a prodigious effulgence, then it began gradually to grow dim; so that, upon its disappearing behind the intervening mountain, its light was very faint."

Meteors of this kind are very frequently seen between the tropics; but they sometimes, also, visit the more temperate regions of Europe. We have the description of a very extraordinary one, given us by Montanari, that serves to show to what great heights, in our atmosphere, these vapours are found to ascend. In the year 1676, a great globe of fire was seen at Bononia, in Italy, about three quarters of an hour after sun-set. It passed westward, with a most rapid course, and at the rate of not less than a hundred and sixty miles in a minute, which is much swifter than the force of a cannon-ball, and, at last, stood over the Adriatic sea. In its course it crossed over all Italy; and, by computation, it could not have been less than thirty-eight miles above the surface of the earth. In the whole line of its course, wherever it approached, the inhabitants below could distinctly hear it, with a hissing noise, resembling that of a fire-work. Having passed away to sea, towards Corsica, it was heard, at last, to go off with a most violent explosion, much louder than that of a cannon; and, immediately after, another noise was heard, like the rattling of a great cart upon a stony pavement; which was, probably, nothing more than the echo of the former sound. Its magnitude, when at Bononia, appeared twice as long as the moon, one way; and as broad

the other; so that, considering its height, it could not have been less than a mile long, and half a mile broad. From the height at which this was seen, and there being no volcano on that quarter of the world from whence it came, it is more than probable that this terrible globe was kindled on some part of the contrary side of the globe, in those regions of vapours, which we have been just describing; and thus, rising above the air, and passing in a course opposite to that of the earth's motion, in this manner it acquired its amazing rapidity.

To these meteors, common enough southward, we will add one more of a very uncommon kind, which was seen, by Ulloa, at Quito, in Peru; the beauty of which will, in some measure, serve to relieve us, after the description of those hideous ones preceding. "At day-break," says he, "the whole mountain of Pambamarca, where we then resided, was encompassed with very thick clouds; which the rising of the sun dispersed so far, as to leave only some vapours, too fine to be seen. On the side opposite to the rising sun, and about ten fathoms distant from the place where we were standing, we saw, as in a looking-glass, each his own image; the head being, as it were, the centre of three circular rainbows, one without the other, and just near enough to each other as that the colours of the internal verged upon those more external; while round all was a circle of white, but with a greater space between. In this manner these circles were erected, like a mirror, before us; and as we moved, they moved, in disposition and order. But, what is most remarkable, though we were six in number, every one saw the phænomenon, with

regard to himself, and not that relating to others. The diameter of the arches gradually altered, as the sun rose above the horizon; and the whole, after continuing a long time, insensibly faded away. In the beginning, the diameter of the inward iris, taken from its last colour, was about five degrees and a half; and that of the white arch, which surrounded the rest, was not less than sixty-seven degrees. At the beginning of the phænomenon, the arches seemed of an oval or elliptical figure, like the disk of the sun; and afterwards became perfectly circular. Each of these was of a red colour, bordered with an orange; and the last bordered by a bright yellow, which altered into a straw colour, and this turned to a green; but, in all, the external colour remained red." Such is the description of one of the most beautiful illusions that has been ever seen in nature. This alone seems to have combined all the splendours of optics in one view. To understand the manner, therefore, how this phænomenon was produced, would require a perfect knowledge of optics; which it is not our present province to enter upon. It will be sufficient, therefore, only to observe, that all these appearances arise from the density of the cloud, together with its uncommon and peculiar situation, with respect to the spectator and the sun. It may be observed, that but one of these three rainbows was real, the rest being only reflections thereof. It may also be observed, that whenever the spectator stands between the sun and a cloud of falling rain, a rainbow is seen, which is nothing more than the reflection of the different coloured rays of light from the bosom of the cloud. If, for instance, we take

a glass globe, filled with water, and hang it up before us, opposite the sun, in many situations, it will appear transparent; but if it is raised higher, or sideways, to an angle of forty-five degrees, it will at first appear red; altered a very little higher, yellow; then green, then blue, then violet colour; in short, it will assume successively all the colours of the rainbow; but, if raised higher still, it will become transparent again. A falling shower may be considered as an infinite number of these little transparent globes, assuming different colours, by being placed at their proper heights. The rest of the shower will appear transparent, and no part of it will seem coloured, but such as are at angles of forty-five degrees from the eye, forty-five degrees upwards, forty-five degrees on each side, and forty-five degrees downward, did not the plain of the earth prevent us. We, therefore, see only an arch of the rainbow, the lower part being cut off from our sight by the earth's interposition. However, upon the tops of very high mountains, circular rainbows are seen, because we can see to an angle of forty-five degrees downward, as well as upward, or sideways, and therefore we take in the rainbow's complete circle.

In those forlorn regions round the poles, the meteors, though of another kind, are not less numerous and alarming. When the winter begins, and the cold prepares to set in, the same misty appearance which is produced in the southern climates by the heat, is there produced by the contrary extreme.* The sea smokes like an oven,

* Paul Egede's History of Greenland.

and a fog arises, which mariners call the frost smoke. This cutting mist commonly raises blisters on several parts of the body; and, as soon as it is wafted to some colder part of the atmosphere, it freezes to little icy particles, which are driven by the wind, and create such an intense cold on land, that the limbs of the inhabitants are sometimes frozen, and drop off.

There also, halos, or luminous circles round the moon, are oftener seen than in any other part of the earth, being formed by the frost smoke; although the air otherwise seems to be clear. A lunar rainbow also is often seen there, though somewhat different from that which is common with us; as it appears of a pale white, striped with grey. In these countries also the aurora borealis streams with peculiar lustre, and variety of colours. In Greenland it generally arises in the east, and darts its sportive fires, with variegated beauty, over the whole horizon. Its appearance is almost constant in winter; and, at those seasons when the sun departs, to return no more for half a year, this meteor kindly rises to supply its beams, and affords sufficient light for all the purposes of existence. However, in the very midst of their tedious night, the inhabitants are not entirely forsaken. The tops of the mountains are often seen painted with the red rays of the sun; and the poor Greenlander from thence begins to date his chronology. It would appear whimsical to read a Greenland calendar, in which we might be told, that one of their chiefs having lived forty days, died, at last, of a good old age; and that his widow continued for half a day

to deplore his loss, with great fidelity, before she admitted a second husband.

The meteors of the day, in these countries, are not less extraordinary than those of the night: mock suns are often reflected upon an opposite cloud; and the ignorant spectator fancies that there are often three or four real suns in the firmament at the same time. In this splendid appearance the real sun is always readily known by its superior brightness, every reflection being seen with diminished splendour. The solar rainbow there is often seen different from ours. Instead of a pleasing variety of colours, it appears of a pale white, edged with a stripe of dusky yellow: the whole being reflected from the bosom of a frozen cloud.

But, of all the meteors which mock the imagination with an appearance of reality, those strange illusions that are seen there, in fine serene weather, are the most extraordinary and entertaining. "Nothing," says Krantz, "ever surprised me more, than, on a fine warm summer's day, to perceive the islands that lie four leagues west of our shore, putting on a form quite different from what they are known to have. As I stood gazing upon them, they appeared, at first, infinitely greater than what they naturally are; and seemed as if I viewed them through a large magnifying-glass. They were not thus only made larger, but brought nearer to me. I plainly descried every stone upon the land, and all the furrows filled with ice, as if I stood close by. When this illusion had lasted for a while, the prospect seemed to break up, and a new scene of wonder to present

itself. The islands seemed to travel to the shore, and represented a wood, or a tall cut hedge. The scene then shifted, and showed the appearance of all sorts of curious figures; as ships with sails, streamers, and flags; antique elevated castles, with decayed turrets; and a thousand forms, for which fancy found a resemblance in nature. When the eye had been satisfied with gazing, the whole groupe of riches seemed to rise in air, and at length vanish into nothing. At such times the weather is quite serene and clear; but comprest with such subtle vapours, as it is in very hot weather; and these appearing between the eye and the object, give it all that variety of appearances which glasses of different refrangibilities would have done." Mr. Krantz observes, that commonly a couple of hours afterwards a gentle west wind and a visible mist follows, which puts an end to this *lusus naturæ.*

It were easy to swell this catalogue of meteors with the names of many others, both in our own climate and in other parts of the world. Such as falling stars, which are thought to be no more than unctuous vapours, raised from the earth to small heights, and continuing to shine till that matter which first raised and supported them, being burnt out, they fall back again to the earth, with extinguished flame. Burning spears, which are a peculiar kind of aurora borealis; bloody rains, which are said to be the excrements of an insect, that at that time has been raised into the air. Showers of stones, fishes, and ivy-berries, at first, no doubt, raised into the air by tempests in one country, and falling at some considerable distance, in the manner of rain, to astonish another. But

omitting these, of which we know little more than what is thus briefly mentioned, I will conclude this chapter with the description of a water-spout; a most surprising phænomenon; not less dreadful to mariners, than astonishing to the observer of nature.

These spouts are seen very commonly in the tropical seas, and sometimes in our own. Those seen by Tournefort, in the Mediterranean, he has described as follows: "The first of these," says this great botanist, "that we saw, was about a musket-shot from our ship. There we perceived the water began to boil, and to rise about a foot above its level. The water was agitated and whitish: and, above its surface, there seemed to stand a smoke, such as might be imagined to come from wet straw before it begins to blaze. It made a sort of a murmuring sound, like that of a torrent heard at a distance, mixed, at the same time, with a hissing noise, like that of a serpent: shortly after, we perceived a column of this smoke rise up to the clouds, at the same time whirling about with great rapidity. It appeared to be as thick as one's finger; and the former sound still continued. When this disappeared, after lasting for about eight minutes, upon turning to the opposite quarter of the sky, we perceived another, which began in the manner of the former; presently after, a third appeared in the west; and instantly beside it still another arose. The most distant of these three could not be above a musket-shot from the ship. They all continued like so many heaps of wet straw set on fire, that continued to smoke, and to make the same noise as before. We

soon after perceived each, with its respective canal, mounting up in the clouds, and spreading where it touched; the cloud, like the mouth of a trumpet, making a figure, to express it intelligibly, as if the tail of an animal were pulled at one end by a weight. These canals were of a whitish colour, and so tinged, as I suppose, by the water which was contained in them; for, previous to this, they were apparently empty, and of the colour of transparent glass. These canals were not straight, but bent in some parts, and far from being perpendicular, but rising in their clouds with a very inclined ascent. But what is very particular, the cloud to which one of them was pointed happening to be driven by the wind, the spout still continued to follow its motion, without being broken; and passing behind one of the others, the spouts crossed each other, in the form of a St. Andrew's cross. In the beginning they were all about as thick as one's finger, except at the top, where they were broader, and two of them disappeared; but shortly after, the last of the three increased considerably; and its canal, which was at first so small, soon became as thick as a man's arm, then as his leg, and, at last, thicker than his whole body. We saw distinctly, through this transparent body, the water, which rose up with a kind of spiral motion; and it sometimes diminished a little of its thickness, and again resumed the same; sometimes widening at top, and sometimes at bottom; exactly resembling a gut filled with water, pressed with the fingers, to make the fluid rise, or fall; and I am well convinced that this alteration in the spout was caused by the wind, which pressed the cloud, and impelled it to

give up its contents. After some time its bulk was so diminished as to be no thicker than a man's arm again; and thus, swelling and diminishing, it at last became very small. In the end, I observed the sea which was raised about it to resume its level by degrees, and the end of the canal that touched it to become as small as if it had been tied round with a cord; and this continued till the light, striking through the cloud, took away the view. I still, however, continued to look, expecting that its parts would join again, as I had before seen in one of the others, in which the spout was more than once broken, and yet again came together; but I was disappointed, for the spout appeared no more."

Many have been the solutions offered for this surprising appearance. M. Buffon supposes the spout, here described, to proceed from the operation of fire, beneath the bed of the sea; as the waters at the surface are thus seen agitated. However, the solution of Dr. Stuart is not divested of probability; who thinks it may be accounted for by suction, as in the application of a cupping-glass to the skin.

Wherever spouts of this kind are seen they are extremely dreaded by mariners; for if they happen to fall upon a ship, they most commonly dash it to the bottom. But, if the ship be large enough to sustain the deluge, they are at least sure to destroy its sails and rigging, and render it unfit for sailing. It is said that vessels of any force usually fire their guns at them, loaden with a bar of iron; and if so happy as to strike them, the water is instantly seen to fall from them, with a dreadful noise, though without any farther mischief.

I am at a loss whether we ought to reckon these spouts called typhons, which are sometimes seen at land, of the same kind with those so often described by mariners at sea, as they seem to differ in several respects. That, for instance, observed at Hatfield, in Yorkshire, in 1687, as it is described by the person who saw it, seems rather to have been a whirlwind than a water-spout. The season in which it appeared was very dry, the weather extremely hot, and the air very cloudy. After the wind had blown for some time with considerable force, and condensed the black clouds one upon another, a great whirling of the air ensued; upon which the centre of the clouds, every now and then, darted down in the shape of a thick long black pipe; in which the relator could distinctly view a motion, like that of a screw, continually screwing up to itself, as it were, whatever it happened to touch. In its progress it moved slowly over a grove of young trees, which it violently bent in a circular motion. Going forward to a barn, it in a minute stript it of all the thatch, and filled the whole air with the same. As it came near the relator, he perceived that its blackness proceeded from a gyration of the clouds, by contrary winds, meeting in a point, or a centre; and where the greatest force was exerted, there darting down, like an Archimedes's screw, to suck up all that came in its way. Another which he saw, some time after, was attended with still more terrible effects; levelling, or tearing up great oak-trees, catching up the birds in its vortex, and dashing them against the ground. In this manner it proceeded with an audible whirling noise, like that of a

mill; and at length dissolved, after having done much mischief.

But we must still continue to suspend our assent as to the nature even of these land spouts; since they have been sometimes found to drop, in a great column of water, at once upon the earth, and produce an instant inundation,* which could not readily have happened had they been caused by the gyration of a whirlwind only. Indeed, every conjecture regarding these meteors, seems to me entirely unsatisfactory. They sometimes appear in the calmest weather at sea, of which I have been an eye-witness; and, therefore, these are not caused by a whirlwind. They are always capped by a cloud; and, therefore, are not likely to proceed from fires at the bottom. They change place: and, therefore, suction seems impracticable. In short, we still want facts, upon which to build a rational theory; and, instead of knowledge, we must be contented with admiration. To be well acquainted with the appearances of Nature, even though we are ignorant of their causes, often constitutes the most useful wisdom.†

* Phil. Trans. vol. iv. p. 108.

[† Dr. Franklin supposes a water-spout and a whirlwind to proceed from the same cause: a fluid moving from all points horizontally towards a centre, must at that centre either mount or descend. If a hole be opened in the middle of the bottom of a tub filled with water, the water will flow from all sides to the centre, and then descend in a whirl: but the air flowing on or near the surface of land or water, from all sides towards a centre, must at that centre ascend, because the land or water will hinder descent.

The lower region of the air is often more heated, and so more rarefied, than the upper, and consequently specifically lighter: if

[But among all the wonders that have lately engaged the attention of the philosopher and the chemist, is the circumstance, that after the explosion of these luminous meteors, heavy stones, varying in bulk and number, have almost constantly fallen from them to the earth. Credibility in a fact, for which not even a conjectural cause in the remotest degree probable could be assigned, was for some time suspended: but the proofs are now so numerous, and of such respectable authority, that it can no longer be doubted.

therefore a large tract of land or sea, unsheltered by clouds, and unruffled by wind, become violently heated and rarefied, so that the lower region become lighter than the superincumbent upper one, the heated lighter air will ascend like smoke up a chimney; and as this rising cannot operate through the whole tract at once, because that would leave too extensive a vacuum, the rising will begin in that column which happens to be most rarefied; and the warm air will flow horizontally from all parts of this column, where the several currents meeting, a whirl or eddy is naturally formed, ascending by a spiral motion, in the same manner as water descends spirally through the hole in the tub.

If the vacuum passes over water, the water may rise in a body or column to the height of about 32 feet; and this whirl of air may be as invisible as air itself. As the whirl weakens, the tube may apparently separate in the middle; the column of water subsiding, the superior condensed part drawing up to the cloud. The tube or whirl of air may nevertheless remain entire, the middle only becoming invisible, as not containing any visible matter.

The author of this note has, frequently, in a fine calm summer's day, when the sun has been very hot, and the atmosphere unruffled by winds, seen sheaves of corn, hay-cocks, and other moveable substances, suddenly lifted up with a circular motion, and carried to a considerable distance: and in a blazing fire, where the flame and smoke are carried up through a small chimney, if a piece of paper or other very light substance be put into the flame, it will be lifted up the chimney with a spiral motion.]

In the year 1794, Dr. Chaldni published a dissertation on this subject; and two years afterwards Mr. King produced a still more complete collection of examples, both ancient and modern, many of them supported by such evidence, that even scepticism could no longer refuse its consent. Mr. Howard, in the Philosophical Transactions for 1802, published an admirable treatise, endeavouring to throw all possible light upon a subject so singular and interesting. He not only collected all the recent and well-authenticated accounts of the fall of these stony bodies, and examined the evidence of their truth, but procured specimens of the stones which were said to have fallen in different places, compared them together, and subjected them to chemical analysis. It may here be proper to give a few of the more recent instances, with the testimonies upon which they rest.

In July, 1794, about twelve stones fell near Sienna in Tuscany, as related by the Earl of Bristol. December 13, 1795, a large stone of fifty-six pounds weight, fell at Wold cottage in Yorkshire, and is described by captain Topham. February 19, 1796, a stone of ten pounds weight fell in Portugal, an account of which is given by Mr. Southey. December 19, 1798, showers of stones fell at Benares in the East Indies, upon the testimony of J. Lloyd Williams, Esq. April 26, 1803, according to M. Fourcroy, several stones, from ten to fourteen pounds weight, fell near L'Aigle in Normandy.

In corroboration of these facts, it appears, that whether they have fallen in England, France, Italy, Germany, or India, they are all composed of the same ingredients, all resemble each other, and com-

pletely differ from any other known stone. Sometimes the stones continue luminous till they sink into the earth, but most commonly their luminousness disappears at the time of explosion; but they are always found hot. Their size differs from a few ounces to several tons; they are usually of a roundish form, and always covered with a black crust. When broken they appear of an ashy-grey colour, and of a granular texture, like a coarse sandstone, and have an earthy smell.

A stone which fell in Yorkshire, deprived as much as possible of its metallic particles, according to Mr. Howard, produced from one hundred and fifty grains, seventy-five of siliceous earth, thirty-seven of magnesia, forty-eight of oxyde or calx of iron, and two of oxyde, or calx of nickell; leaving an excess from its original weight of twelve grains, owing to the oxydation of the metallic bodies.

Various conjectures have been made, to account for their appearance; but such is the obscurity of the subject, that no opinion in the slightest degree probable has yet been advanced. It was at first supposed, that they had been thrown out of volcanoes, but the immense distance from all volcanoes renders this opinion of little value. Chaldni endeavoured to prove, that the meteors from which they fell, were bodies floating in space, unconnected with any planetary system, attracted by the earth in their progress, and kindled by their rapid motion in the atmosphere. Laplace suggests the probability of their having been thrown off by the volcanoes of the moon; but the meteors which almost always accompany them, and the swiftness of their horizontal motion, persuade us to reject this

opinion. Sir William Hamilton, and Mr. King, with greater probability, consider them as concretions actually formed in the atmosphere.

In addition to these, the showers of sulphur which are related to have occasionally fallen, and the vast masses of iron found in South America, and Siberia, are supposed to have their origin from the same causes: for it is a singular coincidence, that these pieces of iron contain nickell, which has never been known to be present in real native iron.

Upon the whole, we can only look with ignorant astonishment, and at present consider these stony and metallic masses as fragments of meteoric fireballs, which have burst in the atmosphere, the origin and causes of which must be left to the accumulated wisdom and inquiry of future ages.]

CHAP. XXII.

The Conclusion.

HAVING thus gone through a particular description of the earth, let us now pause for a moment, to contemplate the great picture before us. The universe may be considered as the palace in which the Deity resides; and this earth as one of its apartments. In this, all the meaner races of animated nature mechanically obey him; and stand ready to execute his commands, without hesitation. Man alone is found refractory; he is the only being endued with a power of contradicting these man-

dates. The Deity was pleased to exert superior power in creating him a superior being; a being endued with a choice of good and evil; and capable, in some measure, of co-operating with his own intentions. Man, therefore, may be considered as a limited creature, endued with powers imitative of those residing in the Deity. He is thrown into a world that stands in need of his help; and has been granted a power of producing harmony from partial confusion.

If, therefore, we consider the earth as allotted for our habitation, we shall find, that much has been given us to enjoy, and much to amend; that we have ample reasons for our gratitude, and still more for our industry. In those great outlines of nature, to which art cannot reach, and where our greatest efforts must have been ineffectual, God himself has finished these with amazing grandeur and beauty. Our beneficent Father has considered these parts of nature as peculiarly his own; as parts which no creature could have skill or strength to amend: and, therefore, made them incapable of alteration, or of more perfect regularity. The heavens and the firmament show the wisdom and the glory of the Workman. Astronomers, who are best skilled in the symmetry of systems, can find nothing there that they can alter for the better. God made these perfect, because no subordinate being could correct their defects.

When, therefore, we survey nature on this side, nothing can be more splendid, more correct, or amazing. We there behold a Deity residing in the midst of an universe, infinitely extended every way, animating all, and cheering the vacuity with his

presence! We behold an immense and shapeless mass of matter, formed into worlds by his power, and dispersed at intervals, to which even the imagination cannot travel! In this great theatre of his glory, a thousand suns, like our own, animate their respective systems, appearing and vanishing at divine command. We behold our own bright luminary, fixed in the centre of its system, wheeling its planets in times proportioned to their distances, and at once dispensing light, heat, and action. The earth also is seen with its twofold motion; producing, by the one, the change of seasons; and, by the other, the grateful vicissitudes of day and night. With what silent magnificence is all this performed! with what seeming ease! The works of art are exerted with interrupted force; and their noisy progress discovers the obstructions they receive: but the earth, with a silent steady rotation, successively presents every part of his bosom to the sun; at once imbibing nourishment and light from that parent of vegetation and fertility.

But not only provisions of heat and light are thus supplied, but its whole surface is covered with a transparent atmosphere, that turns with its motion, and guards it from external injury. The rays of the sun are thus broken into a genial warmth; and, while the surface is assisted, a gentle heat is produced in the bowels of the earth, which contributes to cover it with verdure. Waters also are supplied in healthful abundance, to support life, and assist vegetation. Mountains arise, to diversify the prospect, and give a current to the stream. Seas extend from one continent to

the other, replenished with animals, that may be turned to human support; and also serving to enrich the earth with a sufficiency of vapour. Breezes fly along the surface of the fields, to promote health and vegetation. The coolness of the evening invites to rest; and the freshness of the morning renews for labour.

Such are the delights of the habitation that has been assigned to man; without any one of these, he must have been wretched; and none of these could his own industry have supplied. But while many of his wants are thus kindly furnished on the one hand, there are numberless inconveniences to excite his industry on the other. This habitation, though provided with all the conveniences of air, pasturage, and water, is but a desert place, without human cultivation. The lowest animal finds more conveniences in the wilds of nature than he who boasts himself their lord. The whirlwind, the inundation, and all the asperities of the air, are peculiarly terrible to man, who knows their consequences, and, at a distance, dreads their approach. The earth itself, where human art has not pervaded, puts on a frightful gloomy appearance. The forests are dark and tangled; the meadows overgrown with rank weeds; and the brooks stray without a determined channel. Nature, that has been kind to every lower order of beings, has been quite neglectful with regard to him; to the savage uncontriving man the earth is an abode of desolation, where his shelter is insufficient, and his food precarious.

A world thus furnished with advantages on one side, and inconveniences on the other, is the pro-

per abode of reason, is the fittest to exercise the industry of a free and a thinking creature. These evils, which art can remedy, and prescience guard against, are a proper call for the exertion of his faculties; and they tend still more to assimilate him to his Creator. God beholds, with pleasure, that being which he has made, converting the wretchedness of his natural situation into a theatre of triumph; bringing all the headlong tribes of nature into subjection to his will; and producing that order and uniformity upon earth, of which his own heavenly fabric is so bright an example.

CHAP. XXIII.

A Comparison of Animals with the inferior Ranks of Creation.

HAVING given an account of the earth in general, and the advantages and inconveniences with which it abounds, we now come to consider it more minutely. Having described the habitation, we are naturally led to inquire after the inhabitants. Amidst the infinitely different productions which the earth offers, and with which it is every where covered, animals hold the first rank; as well because of the finer formation of their parts, as of their superior power. The vegetable, which is fixed to one spot, and obliged to wait for its accidental supplies of nourishment, may be considered as the prisoner of nature. Unable to correct the disadvantages of its situation, or to shield itself

from the dangers that surround it, every object that has motion may be its destroyer.

But, animals are endowed with powers of motion and defence. The greatest part are capable, by changing place, of commanding Nature; and of thus obliging her to furnish that nourishment which is most agreeable to their state. Those few that are fixed to one spot, even in this seemingly helpless situation, are, nevertheless, protected from external injury, by a hard shelly covering; which they often can close at pleasure, and thus defend themselves from every assault. And here, I think, we may draw the line between the animal and vegetable kingdoms. Every animal, by some means or other, finds protection from injury; either from its force, or courage, its swiftness, or cunning. Some are protected by hiding in convenient places; and others by taking refuge in a hard resisting shell. But, vegetables are totally unprotected; they are exposed to every assailant, and patiently submissive in every attack. In a word, an animal is an organized being that is in some measure provided for its own security; a vegetable is destitute of every protection.

But though it is very easy, without the help of definitions, to distinguish a plant from an animal, yet both possess many properties so much alike, that the two kingdoms, as they are called, seem mixed with each other. Hence, it frequently puzzles the naturalist to tell exactly where animal life begins, and vegetative terminates; nor, indeed, is it easy to resolve, whether some objects offered to view, be of the lowest of the animal, or the highest of the vegetable races. The sensitive plant,

that moves at the touch, seems to have as much perception as the fresh-water polypus, that is possessed of a still slower share of motion. Besides, the sensitive plant will not re-produce upon cutting in pieces, which the polypus is known to do; so that the vegetable production seems to have the superiority. But, notwithstanding this, the polypus hunts for its food, as most other animals do. It changes its situation; and, therefore, possesses a power of choosing its food, or retreating from danger. Still, therefore, the animal kingdom is far removed above the vegetable; and its lowest denizen is possessed of very great privileges, when compared with the plants with which it is often surrounded.

However, both classes have many resemblances, by which they are raised above the unorganized and inert masses of nature. Minerals are mere inactive, insensible bodies, entirely motionless of themselves, and waiting some external force to alter their forms, or their properties. But, it is otherwise with animals and vegetables; these are endued with life and vigour; they have their state of improvement and decay; they are capable of re-producing their kinds; they grow from seeds in some, and from cuttings in others; they seem all possessed of sensation, in a greater or less degree; they both have their enmities and affections; and, as some animals are, by nature, impelled to violence, so some plants are found to exterminate all others, and make a wilderness of the places round them. As the lion makes a desert of the forest where it resides, thus no other plant will grow under the shade of the manchineel-tree.

Thus, also, that plant, in the West Indies, called caraguata, clings round whatever tree it happens to approach: there it quickly gains the ascendant; and, loading the tree with a verdure not its own, keeps away that nourishment designed to feed the trunk; and, at last, entirely destroys its supporter.

As all animals are ultimately supported upon vegetables, so vegetables are greatly propagated, by being made a part of animal food. Birds distribute the seeds wherever they fly, and quadrupeds prune them into greater luxuriance. By these means the quantity of food, in a state of nature, is kept equal to the number of the consumers; and, lest some of the weaker ranks of animals should find nothing for their support, but all the provisions be devoured by the strong, different vegetables are appropriated to different appetites. If, transgressing this rule, the stronger ranks should invade the rights of the weak, and, breaking through all regard to appetite, should make an indiscriminate use of every vegetable, nature then punishes the transgression, and poison marks the crime as capital.

If again we compare vegetables and animals with respect to the places where they are found, we shall find them bearing a still stronger similitude. The vegetables that grow in a dry and sunny soil, are strong and vigorous, though not luxuriant; so, also, are the animals of such a climate. Those, on the contrary, that are the joint product of heat and moisture, are luxuriant and tender: and the animals assimilating to the vegetable food on which they ultimately subsist, are

much larger in such places than in others. Thus, in the internal parts of South America and Africa, where the sun usually scorches all above, while inundations cover all below, the insects, reptiles, and other animals, grow to a prodigious size: the earth-worm of America is often a yard in length, and as thick as a walking-cane; the boiguacu, which is the largest of the serpent kind, is sometimes forty feet in length; the bats, in those countries, are as big as a rabbit; the toads are bigger than a duck, and their spiders are as large as a sparrow. On the contrary, in the cold frozen regions of the north, where vegetable nature is stinted of its growth, the few animals in those climates partake of the diminution; all the wild animals, except the bear, are much smaller than in milder countries; and such of the domestic kinds as are carried thither, quickly degenerate, and grow less. Their very insects are of the minute kinds, their bees and spiders being not half so large as those in the temperate zone.

The similitude between vegetables and animals is no where more obvious than in those that belong to the ocean, where the nature of one is admirably adapted to the necessities of the other. This element it is well known has its vegetables, and its insects that feed upon them in great abundance. Over many tracts of the sea, a weed is seen floating, which covers the surface, and gives the resemblance of a green and extensive meadow. On the under side of these unstable plants, millions of little animals are found, adapted to their situation. For, as their ground, if I may so express it, lies over their heads, their feet are placed

upon their backs; and, as land animals have their legs below their bodies, these have them above. At land also, most animals are furnished with eyes to see their food; but at sea, almost all the reptile kinds are without eyes, which might only give them prospects of danger, at a time when unprovided with the means of escaping it.*

Thus, in all places, we perceive an obvious similitude between the animals and the vegetables of every region. In general, however, the most perfect races have the least similitude to the vegetable productions on which they are ultimately fed; while, on the contrary, the meaner the animal, the more local it is found to be, and the more it is influenced by the varieties of the soil where it resides. Many of the more humble reptile kinds are not only confined to one country, but also to a plant; nay, even to a leaf. Upon that they subsist, increase with its vegetation, and seem to decay as it declines. They are merely the circumscribed inhabitants of a single vegetable; take them from that, and they instantly die; being entirely assimilated to the plant they feed on, assuming its colour, and even its medicinal properties. For this reason, there are infinite numbers of the meaner animals that we have never an opportunity of seeing in this part of the world; they are incapable of living separate from their kindred vegetables, which grow only in a certain climate.

Such animals as are formed more perfect, lead a life of less dependance; and some kinds are found

* Linnæi Amœnitates, vol. v. p. 68.

to subsist in many parts of the world at the same time. But, of all the races of animated nature, man is the least affected by the soil where he resides, and least influenced by the variations of vegetable sustenance: equally unaffected by the luxuriance of the warm climates, or the sterility of the poles, he has spread his habitations over the whole earth; and finds subsistence as well amidst the ice of the north as the burning deserts under the line. All creatures of an inferior nature, as has been said, have peculiar propensities to peculiar climates; they are circumscribed to zones, and confined to territories where their proper food is found in the greatest abundance; but man may be called the animal of every climate, and suffers but very gradual alterations from the nature of any situation.

As to animals of a meaner rank, whom man compels to attend him in his migrations, these being obliged to live in a kind of constraint, and upon vegetable food, often different from that of their native soil, they very soon alter their natures with the nature of their nourishment, assimilate to the vegetables upon which they are fed, and thus assume very different habits as well as appearances. Thus, man, unaffected himself, alters and directs the nature of other animals at his pleasure; increases their strength for his delight, or their patience for his necessities.

This power of altering the appearances of things seems to have been given him for very wise purposes. The Deity, when he made the earth, was willing to give his favoured creature many opponents, that might at once exercise his virtues,

and call forth his latent abilities. Hence we find, in those wide uncultivated wildernesses, where man, in his savage state, owns inferior strength, and the beasts claim divided dominion, that the whole forest swarms with noxious animals and vegetables; animals, as yet undescribed, and vegetables which want a name. In those recesses Nature seems rather lavish than magnificent, in bestowing life. The trees are usually of the largest kinds, covered round with parasite plants, and interwoven at the tops with each other. The boughs, both above and below, are peopled with various generations; some of which have never been upon the ground, and others have never stirred from the branches on which they were produced. In this manner millions of minute, and loathsome creatures, pursue a round of uninterrupted existence, and enjoy a life scarcely superior to vegetation. At the same time, the vegetables, in those places, are of the larger kinds, while the animal race is of the smaller: but, man has altered this disposition of nature; having, in a great measure, levelled the extensive forests, cultivated the softer and finer vegetables, destroyed the numberless tribes of minute and noxious animals, and taken every method to increase a numerous breed of the larger kinds. He thus has exercised a severe control; unpeopled nature, to embellish it; and diminished the size of the vegetable, in order to improve that of the animal kingdom.

To subdue the earth to his own use was, and ought to be, the aim of man; which was only to be done by increasing the number of plants, and diminishing that of animals: to multiply ex-

istence, *alone* was that of the Deity. For this reason, we find, in a state of nature, that animal life is increased to the greatest quantity possible: and, we can scarcely form a system that could add to its numbers. First, plants or trees are provided by Nature, of the largest kinds; and, consequently, the nourishing surface is thus extended. In the second place, there are animals peculiar to every part of the vegetable, so that no part of it is lost. But the greatest possible increase of life would still be deficient, were there not other animals that lived upon animals; and these are, themselves, in turn, food for some other greater and stronger set of creatures. Were all animals to live upon vegetables alone, thousands would be extinct that now have existence, as the quantity of their provision would shortly fail. But, as things are wisely constituted, one animal now supports another; and thus, all take up less room than they would by living on the same food; as, to make use of a similar instance, a greater number of people may be crowded into the same space, if each is made to bear his fellow upon his shoulders.

To diminish the number of animals and increase that of vegetables, has been the general scope of human industry; and, if we compare the utility of the kinds, with respect to man, we shall find, that of the vast variety in the animal kingdom, but very few are serviceable to him; and, in the vegetable, but very few are entirely noxious. How small a part of the insect tribes, for instance, are beneficial to mankind, and what numbers are injurious! In some countries they almost darken the

air: a candle cannot be lighted without their instantly flying upon it, and putting out the flame.* The closest recesses are no safeguard from their annoyance; and the most beautiful landscapes of nature only serve to invite their rapacity. As these are injurious from their multitudes, so most of the larger kinds are equally dreadful to him, from their courage and ferocity. In the most uncultivated parts of the forest these maintain an undisputed empire; and man invades their retreats with terror. These are dreadful; and there are still more which are utterly useless to him, that serve to take up the room which more beneficial creatures might possess; and incommode him, rather with their numbers than their enmities. Thus, in a catalogue of land-animals, that amounts to more than twenty thousand, we can scarcely reckon up a hundred that are any way useful to him; the rest, being either all his open, or his secret enemies, immediately attacking him in person, or intruding upon that food he has appropriated to himself. Vegetables, on the contrary, though existing in greater variety, are but few of them noxious. The most deadly poisons are often of great use in medicine; and even those plants that only seem to cumber the ground, serve for food to that race of animals which he has taken into friendship or protection. The smaller tribes of vegetables, in particular, are cultivated as contributing either to his necessities or amusement; so that vegetable life is as much promoted by

* Ulloa's Description of Guayaquil.

human industry, as animal life is controlled and diminished.

Hence, it was not without a long struggle and various combinations of experience and art, that man acquired his present dominion. Almost every good that he possesses was the result of the contest; for, every day, as he was contending, he was growing more wise; and patience and fortitude were the fruits of his industry.

Hence, also, we see the necessity of some animals living upon each other, to fill up the plan of Providence; and we may, consequently, infer the expediency of man's living upon all. Both animals and vegetables seem equally fitted to his appetites; and were any religious or moral motives to restrain him from taking away life, upon any account, he would only thus give existence to a variety of beings made to prey upon each other; and, instead of preventing, multiply mutual destruction.

CHAP. XXIV.

Of the Generation of Animals.

BEFORE we survey animals in their state of maturity, and performing the functions adapted to their respective natures, method requires that we should consider them in the more early periods of their existence. There has been a time when the proudest and the noblest animal was a partaker of the same imbecility with the meanest reptile; and, while yet a candidate for existence, equally help-

less and contemptible. In their incipient state all are upon a footing; the insect and the philosopher being equally insensible, clogged with matter, and unconscious of existence. Where then are we to begin with the history of those beings, that make such a distinguished figure in the creation? Or, where lie those peculiar characters in the parts that go to make up animated nature, that mark one animal as destined to creep in the dust, and another to glitter on the throne?

This has been a subject that has employed the curiosity of all ages, and the philosophers of every age have attempted the solution. In tracing Nature to her most hidden recesses, she becomes too minute or obscure for our inspection; so that we find it impossible to mark her first differences, to discover the point where animal life begins, or the cause that conduces to set it in motion. We know little more than that the greatest number of animals require the concurrence of a male and female to re-produce their kind; and that these, distinctly and invariably, are found to beget creatures of their own species. Curiosity has, therefore, been active, in trying to discover the immediate result of this union, how far either sex contributes to the bestowing animal life, and whether it be to the male or female that we are most indebted for the privilege of our existence.

Hippocrates has supposed that fecundity proceeded from the mixture of the seminal liquor of both sexes, each of which equally contributes to the formation of the incipient animal. Aristotle, on the other hand, would have the seminal liquor in the male alone to contribute to this purpose,

while the female supplied the proper nourishment for its support. Such were the opinions of these fathers of philosophy; and these continued to be adopted by the naturalists and school-men of succeeding ages, with blind veneration. At length, Steno and Harvey, taking anatomy for their guide, gave mankind a nearer view of nature just advancing into animation. These perceived in all such animals as produced their young alive, two glandular bodies, near the womb, resembling that ovary, or cluster of small eggs, which is found in fowls; and, from the analogy between both, they gave these also the name of ovaria. These, as they resembled eggs, they naturally concluded had the same offices; and, therefore, they were induced to think that all animals, of what kind soever, were produced from eggs. At first, however, there was some altercation raised against this system; for, as these ovaria were separate from the womb, it was objected that they could not be any way instrumental in replenishing that organ, with which they did not communicate. But, upon more minute inspection, Fallopius, the anatomist, perceived two tubular vessels depending from the womb, which, like the horns of a snail, had a power of erecting themselves, of embracing the ovaria, and of receiving the eggs, in order to be fecundated by the seminal liquor. This discovery seemed, for a long time after, to fix the opinions of philosophers. The doctrine of Hippocrates was re-established, and the chief business of generation was ascribed to the female. This was, for a long time, the established opinion of the schools; but Leuwenhoeck, once more, shook the whole system,

and produced a new schism among the lovers of speculation. Upon examining the seminal liquor of a great variety of male animals, with microscopes, which helped his sight more than that of any of his successors, he perceived therein infinite numbers of little living creatures, like tadpoles, very brisk, and floating in the fluid, with a seeming voluntary motion. Each of these, therefore, was thought to be the rudiments of an animal, similar to that from which it was produced; and this only required a reception from the female, together with proper nourishment, to complete its growth. The business of generation was now, therefore, given back to the male a second time, by many; while others suspended their assent, and chose rather to confess ignorance than to embrace error.*

In this manner has the dispute continued for several ages, some accidental discovery serving, at intervals, to renew the debate, and revive curiosity. It was a subject where speculation could find much room to display itself; and M. Buffon, who loved to speculate, would not omit such an opportunity of giving scope to his propensity. According to this most pleasing of all naturalists, the microscope discovers that the seminal liquor, not only of males, but of females, also, abounds in these moving little animals, which have been mentioned above, and that they appear equally brisk in either fluid. These he takes not to be real animals, but organical particles, which, being simple, cannot be said to be organized themselves, but go to the composition of

* Bonnet Considérations sur les Corps Organisés.

all organized bodies whatsoever: in the same manner as a tooth, in the wheel of a watch, cannot be called either the wheel, or the watch, and yet contributes to the sum of the machine. These organical particles are, according to him, diffused throughout all nature, and to be found not only in the seminal liquor, but in most other fluids, in the parts of vegetables, and all parts of animated nature. As they happen, therefore, to be differently applied, they serve to constitute a part of the animal, or the vegetable, whose growth they serve to increase, while the superfluity is thrown off in the seminal liquor of both sexes, for the re-production of other animals or vegetables of the same species. These particles assume different figures, according to the receptacle into which they enter; falling into the womb, they unite into a fœtus; beneath the bark of a tree they pullulate into branches; and, in short, the same particles that first formed the animal in the womb, contribute to increase its growth when brought forth.*

To this system it has been objected, that it is impossible to conceive organical substances without being organized; and that, if divested of organization themselves, they could never make an organized body, as an infinity of circles could never make a triangle. It has been objected, that it is more difficult to conceive the transformation of these organical particles than even that of the animal whose growth we are inquiring after; and this system, therefore, attempts to explain one obscure thing by another still more obscure.

* M. Buffon.

But an objection, still stronger than these, has been advanced, by an ingenious countryman of our own; who asserts, that these little animals, which thus appear swimming, and sporting, in almost every fluid we examine with a microscope, are not real living particles, but some of the more opake parts of the fluid, that are thus increased in size, and seem to have a much greater motion than they have in reality. For the motion being magnified with the object, the smallest degree of it will seem very considerable; and a being almost at rest may, by these means, be apparently put into violent action. Thus, for instance, if we look upon the sails of a wind-mill moving, at a distance, they appear to go very slow; but, if we approach them, and thus magnify their bulk to our eye, they go round with great rapidity. A microscope, in the same manner, serves to bring our eye close to the object, and thus to enlarge it; and not only increase the magnitude of its parts, but of its motion. Hence, therefore, it would follow, that these organical particles that are said to constitute the bulk of living nature, are but mere optical illusions; and the system founded on them must, like them, be illusive.

These, and many other objections have been made to this system; which, instead of enlightening the mind, serve only to show, that too close a pursuit of Nature very often leads to uncertainty. Happily, however, for mankind, the most intricate inquiries are generally the most useless. Instead, therefore, of balancing accounts between the sexes, and attempting to ascertain to which the business of generation most properly belongs, it will be more

instructive, as well as amusing, to begin with animal nature, from its earliest retirements, and evanescent outlines, and pursue the incipient creature through all its changes in the womb till it arrives into open day.

The usual distinction of animals, with respect to their manner of generation, has been into the oviparous and viviparous kinds; or, in other words, into those that bring forth an egg, which is afterwards hatched into life, and those that bring forth their young alive and perfect. In one of these two ways all animals were supposed to have been produced, and all other kinds of generation were supposed imaginary or erroneous. But later discoveries have taught us to be more cautious in making general conclusions, and have even induced many to doubt whether animal life may not be produced merely from putrefaction.*

Indeed, the infinite number of creatures that putrid substances seem to give birth to, and the variety of little insects seen floating in liquors, by the microscope, appear to favour this opinion. But, however this may be, the former method of classing animals can now by no means be admitted, as we find many animals that are produced neither from the womb, nor from the shell, but merely from cuttings; so that to multiply life in some creatures, it is sufficient only to multiply the dissection. This being the simplest method of generation, and that in which life seems to require the smallest preparation for its existence, I will begin with it, and so proceed to the two other kinds, from the meanest to the most elaborate.

* Bonnet Consid. p. 100.

The earth-worm, the millepedes, the sea-worm, and many marine insects, may be multiplied by being cut in pieces; but the polypus is noted for its amazing fertility; and from hence it will be proper to take the description. The structure of the polypus may be compared to the finger of a glove, open at one end, and closed at the other. The closed end represents the tail of the polypus, with which it serves to fix itself to any substance it happens to be upon; the open end may be compared to the mouth; and, if we conceive six or eight small strings issuing from this end, we shall have a proper idea of its arms, which it can erect, lengthen, and contract, at pleasure, like the horns of a snail. This creature is very voracious, and makes use of its arms as a fisherman does of his net, to catch, and entangle such little animals as happen to come within its reach. It lengthens these arms several inches, keeps them separated from each other, and thus occupies a large space in the water, in which it resides. These arms, when extended, are as fine as threads of silk, and have a most exquisite degree of feeling. If a small worm happens to get within the sphere of their activity, it is quickly entangled by one of these arms, and, soon after, the other arms come to its aid; these all together shortening, the worm is drawn into the animal's mouth, and quickly devoured, colouring the body as it is swallowed. Thus much is necessary to be observed of this animal's method of living, to show that it is not of the vegetable tribe, but a real animal, performing the functions which other animals are found to perform, and endued with powers that many of them are destitute of.

But what is most extraordinary remains yet to be told; for, if examined with a microscope, there are seen several little specks, like buds, that seem to pullulate from different parts of its body; and these, soon after, appear to be young polypi, and like the large polypus, begin to cast their little arms about for prey, in the same manner. Whatever they happen to ensnare is devoured, and gives a colour not only to their own bodies, but to that of the parent; so that the same food is digested, and serves for the nourishment of both. The food of the little one passes into the large polypus, and colours its body; and this, in its turn, digests, and swallows its food to pass into theirs. In this manner every polypus has a new colony sprouting from its body; and these new ones, even while attached to the parent animal, become parents themselves, having a smaller colony also budding from them. All, at the same time, busily employed in seeking for their prey, and the food of any one of them serving for the nourishment, and circulating through the bodies of all the rest. This society, however, is every hour dissolving; those newly produced are seen at intervals to leave the body of the large polypus, and become, shortly after, the head of a beginning colony themselves.

In this manner the polypus multiplies naturally; but, one may take a much readier and shorter way to increase them, and this only by cutting them in pieces. Though cut into thousands of parts, each part still retains its vivacious qualities, and each shortly becomes a distinct and complete polypus: whether cut lengthways or crossways, it is all the same: this extraordinary creature seems a gainer

by our endeavours, and multiplies by apparent destruction. The experiment has been tried, times without number, and still attended with the same success. Here, therefore, naturalists, who have been blamed for the cruelty of their experiments upon living animals, may now boast of their increasing animal life, instead of destroying it. The production of the polypus is a kind of philosophical generation. The famous Sir Thomas Brown wished to be able to produce children by the same method as trees are produced: the polypus is multiplied in this manner; and every philosopher may thus, if he please, boast of a very numerous, though, I should suppose, a very useless progeny.

This method of generation, from cuttings, may be considered as the most simple kind, and is a strong instance of the little pains Nature takes in the formation of her lower and humbler productions. As the removal of these from inanimate into animal existence is but small, there are but few preparations made for their journey. No organs of generation seem provided, no womb to receive, no shell to protect them in their state of transition. The little reptile is quickly fitted for all the offices of its humble sphere, and, in a very short time, arrives at the height of its contemptible perfection.

The next generation is of those animals that we see produced from the egg. In this manner all birds, most fishes, and many of the insect tribes, are brought forth. An egg may be considered as a womb, detached from the body of the parent animal, in which the embryo is but just beginning to be formed. It may be regarded as a kind of incomplete delivery, in which the animal is disbur-

thened of its young, before its perfect formation. Fishes, and insects, indeed, most usually commit the care of their eggs to hazard; but birds, which are more perfectly formed, are found to hatch them into maturity, by the warmth of their bodies. However, any other heat, of the same temperature, would answer the end as well; for either the warmth of the sun, or of a stove, is equally efficacious in bringing the animal in the egg to perfection. In this respect, therefore, we may consider generation from the egg as inferior to that in which the animal is brought forth alive. Nature has taken care of the viviparous animal in every stage of its existence. That force which separates it from the parent, separates it from life; and the embryo is shielded with unceasing protection till it arrives at exclusion. But it is different with the little animal in the egg; often totally neglected by the parent, and always separable from it, every accident may retard its growth, or even destroy its existence. Besides, art, or accident, also, may bring this animal to a state of perfection; so that it can never be considered as a complete work of Nature, in which so much is left for accident to finish or destroy.

But, however inferior this kind of generation may be, the observation of it will afford great insight into that of nobler animals, as we can here watch the progress of the growing embryo, in every period of its existence, and catch it in those very moments when it first seems stealing into motion. Malpighi and Haller have been particularly industrious on this subject; and, with a patience almost equalling that of the sitting hen, have attended incubation in all its stages. From them, therefore,

we have an amazing history of the chicken in the egg, and of its advances into complete formation.

'It would be methodically tedious to describe those parts of the egg, which are well known, and obvious; such as its shell, its white, and its yolk; but the disposition of these is not so apparent. Immediately under the shell lies that common membrane, or skin, which lines it on the inside, adhering closely to it every where, except at the broad end, where a little cavity is left, that is filled with air, which increases as the animal within grows larger. Under this membrane are contained two whites, though seeming to us to be only one, each wrapped up in a membrane of its own, one white within the other. In the midst of all is the yolk, wrapt round, likewise, in its own membrane. At each end of this are two ligaments, called chalazæ, which are, as it were, the poles of this microcosm, being white dense substances, made from the membranes, and serving to keep the white and the yolk in their places. It was the opinion of Mr. Derham, that they served also for another purpose: for, a line being drawn from one ligament to the other, would not pass directly through the middle of the yolk, but rather towards one side, and would divide the yolk into two unequal parts, by which means these ligaments served to keep the smallest side of the yolk always uppermost; and in this part he supposed the cicatricula, or first speck of life, to reside; which, by being uppermost, and consequently next the hen, would be thus in the warmest situation. But this is rather fanciful than true, the incipient animal being found in all situa-

tions, and not particularly influenced by any.* This cicatricula, which is the part where the animal first begins to show signs of life, is not unlike a vetch, or a lentil, lying on one side of the yolk, and within its membrane. All these contribute to the little animal's convenience or support; the outer membranes, and ligaments, preserve the fluids in their proper places; the white serves as nourishment; and the yolk, with its membranes, after a time, becomes a part of the animal's body.† This is the description of a hen's egg, and answers to that of all others, how large or how small soever.

Previous to putting the eggs to the hen, our philosophers first examined the cicatricula, or little spot already mentioned; and which may be considered as the most important part of the egg. This was found, in those that were impregnated by the cock, to be large; but, in those laid without the cock, very small. It was found, by the microscope, to be a kind of bag, containing a transparent liquor, in the midst of which the embryo was seen to reside. The embryo resembled a composition of little threads, which the warmth of future incubation tended to enlarge, by varying, and liquefying the other fluids contained within the shell, and thus pressing them either into the pores or tubes of their substance.

Upon placing the eggs in their proper warmth,‡ either under the sun, or in a stove, after six hours the vital speck begins to dilate, like the pupil of

* Haller. † Ibid. ‡ Malpighi.

the eye. The head of the chicken is distinctly seen, with the back-bone, something resembling a tadpole, floating in its ambient fluid, but as yet seeming to assume none of the functions of animal life. In about six hours more, the little animal is seen more distinctly; the head becomes more plainly visible, and the vertebræ of the back more easily perceivable. All these signs of preparation for life are increased in six hours more; and, at the end of twenty-four hours, the ribs begin to take their places, the neck begins to lengthen, and the head to turn to one side.

At this time,* also, the fluids in the egg seem to have changed place: the yolk, which was before in the centre of the shell, approaches nearer to the broad end. The watery part of the white is, in some measure, evaporated through the shell, and the grosser part sinks to the small end. The little animal appears to turn towards the part of the broad end, in which a cavity has been described, and with its yolk seems to adhere to the membrane there. At the end of forty hours the great work of life seems fairly begun, and the animal plainly appears to move; the back-bone, which is of a whitish colour, thickens; the head is turned still more on one side; the first rudiments of the eyes begin to appear; the heart beats, and the blood begins already to circulate. The parts, however, as yet are fluid; but, by degrees, become more and more tenacious, and harden into a kind of jelly. At the end of two days, the liquor, in which the chicken swims, seems to increase; the head ap-

* Harvey.

pears with two little bladders in the place of eyes, the heart beats in the manner of every embryo where the blood does not circulate through the lungs. In about fourteen hours after this, the chicken is grown more strong; its head, however, is still bent downwards; the veins and arteries begin to branch, in order to form the brain; and the spinal marrow is seen stretching along the backbone. In three days, the whole body of the chicken appears bent; the head, with its two eye-balls, with their different humours, now distinctly appear: and five other vesicles are seen, which soon unite to form the rudiments of the brain. The outlines also of the thighs and wings begin to be seen, and the body begins to gather flesh. At the end of the fourth day, the vesicles that go to form the brain approach each other; the wings and thighs appear more solid; the whole body is covered with a jelly-like flesh; the heart, that was hitherto exposed, is now covered up within the body, by a very thin transparent membrane; and, at the same time, the umbilical vessels, that unite the animal to the yolk, now appear to come forth from the abdomen. After the fifth and sixth days, the vessels of the brain begin to be covered over; the wings and thighs lengthen; the belly is closed up, and tumid; the liver is seen within it, very distinctly, not yet grown red, but of a very dusky white; both the ventricles of the heart are discerned, as if they were two separate hearts, beating distinctly; the whole body of the animal is covered over; and the traces of the incipient feathers are already to be seen. The 7th day, the head appears very large; the brain is covered entirely

over; the bill begins to appear betwixt the eyes; and the wings, the thighs, and the legs, have acquired their perfect figure.* Hitherto, however, the animal appears as if it had two bodies; the yolk is joined to it by the umbilical vessels that come from the belly; and is furnished with its vessels, through which the blood circulates, as through the rest of the body of the chicken, making a bulk greater than that of the animal itself. But towards the end of incubation, the umbilical vessels shorten the yolk, and with it the intestines are thrust up into the body of the chicken, by the action of the muscles of the belly; and the two bodies are thus formed into one. During this state, all the organs are found to perform their secretions; the bile is found to be separated, as in grown animals; but it is fluid, transparent, and without bitterness: and the chicken then also appears to have lungs. On the tenth, the muscles of the wings appear, and the feathers begin to push out. On the eleventh, the heart, which hitherto had appeared divided, begins to unite; the arteries which belong to it join into it, like the fingers into the palm of the hand. All these appearances only come more into view, because the fluids the vessels had hitherto secreted were more transparent; but as the colour of the fluids deepen, their operations and circulations are more distinctly seen. As the animal thus, by the eleventh day completely formed, begins to gather strength, it becomes more uneasy in its situation, and exerts its animal powers with increasing force. For some time before it is able to break the

* Haller.

shell in which it is imprisoned, it is heard to chirrup, receiving a sufficient quantity of air for this purpose, from that cavity which lies between the membrane and the shell, and which must contain air to resist the external pressure. At length, upon the twentieth day, in some birds sooner, and later in others, the inclosed animal breaks the shell within which it has been confined, with its beak; and, by repeated efforts, at last procures its enlargement.

From this little history we perceive, that those parts which are most conducive to life, are the first that are begun: the head, and the back-bone, which no doubt inclose the brain, and the spinal marrow, though both are too limpid to be discerned, are the first that are seen to exist: the beating of the heart is perceived soon after: the less noble parts seem to spring from these; the wings, the thighs, the feet, and, lastly, the bill. Whatever, therefore, the animal has double, or whatever it can live without the use of, these are latest in production: Nature first sedulously applying to the formation of the nobler organs, without which life would be of short continuance, and would be begun in vain.

The resemblance between the beginning animal in the egg, and the embryo in the womb, is very striking; and this similitude has induced many to assert, that all animals are produced from eggs, in the same manner. They consider an egg excluded from the body by some, and separated into the womb by others, to be actions merely of one kind; with this only difference, that the nourishment of the one is kept within the body of the parent, and

increases as the embryo happens to want the supply; the nourishment of the other is prepared all at once, and sent out with the beginning animal, as entirely sufficient for its future support. But leaving this to the discussion of anatomists, let us proceed rather with facts than dissertations; and as we have seen the progress of an oviparous animal, or one produced from the shell, let us likewise trace that of a viviparous animal, which is brought forth alive. In this investigation, Graaf has, with a degree of patience characteristic of his nation, attended the progress and increase of various animals in the womb, and minutely marked the changes they undergo. Having dissected a rabbit, half an hour after impregnation, he perceived the horns of the womb, that go to embrace and communicate with the ovary, to be more red than before; but no other change in the rest of the parts. Having dissected another, six hours after, he perceived the follicules, or the membrane covering the eggs contained in the ovary, to become reddish. In a rabbit dissected after twenty-four hours, he perceived, in one of the ovaries, three follicules, and, in the other, five, that were changed; being become, from transparent, dark and reddish. In one dissected after three days, he perceived the horns of the womb very strictly to embrace the ovaries; and he observed three of the follicules in one of them, much longer and harder than before: pursuing his inquisition, he also found two of the eggs actually separated into the horns of the womb, and each about the size of a grain of mustard-seed; these little eggs were each of them inclosed in a double membrane, the inner parts being filled with

a very limpid liquor. After four days, he found, in one of the ovaries, four, and in the other, five follicules, emptied of their eggs: and in the horns correspondent to these, he found an equal number of eggs thus separated: these eggs were now grown larger than before, and somewhat of the size of sparrow-shot. In five days, the eggs were grown to the size of duck-shot, and could be blown from the part of the womb where they were, by the breath. In seven days, these eggs were found of the size of a pistol-bullet, each covered with its double membrane, and these much more distinct than before. In nine days, having examined the liquor contained in one of these eggs, he found it, from a limpid colour, less fluid, to have got a light cloud floating upon it. In ten days, this cloud began to thicken, and to form an oblong body, of the figure of a little worm: and, in twelve days, the figure of the embryo was distinctly to be perceived, and even its parts came into view. In the region of the breast he perceived two bloody specks; and two more, that appeared whitish. Fourteen days after impregnation, the head of the embryo was become large and transparent, the eyes prominent, the mouth open, and the rudiments of the ears beginning to appear; the back-bone, of a whitish colour, was bent towards the breast; the two bloody specks being now considerably increased, appeared to be nothing less than the outlines of the two ventricles of the heart; and the two whitish specks on each side, now appeared to be the rudiments of the lungs; towards the region of the belly, the liver began to be seen, of a reddish colour: and a little intricate mass, like ravelled

thread, discerned, which soon appeared to be the stomach and the intestines: the legs soon after began to be seen, and to assume their natural positions: and from that time forth, all the parts being formed, every day only served to develope them still more, until the thirty-first day, when the rabbit brought forth her young, completely fitted for the purposes of their humble happiness.

Having thus seen the stages of generation in the meaner animals, let us take a view of its progress in man; and trace the feeble beginnings of our own existence. An account of the lowliness of our own origin, if it cannot amuse, will at least serve to humble us; and it may take from our pride, though it fails to gratify our curiosity. We cannot here trace the variations of the beginning animal, as in the former instances; for the opportunities of inspection are but few and accidental: for this reason, we must be content often to fill up the blanks of our history with conjecture. And first, we are entirely ignorant of the state of the infant in the womb, immediately after conception; but we have good reason to believe that it proceeds as in most other animals from the egg.* Anatomists inform us, that four days after conception, there is found in the womb an oval substance, about the size of a small pea, but longer one way than the other; this little body is formed by an extremely fine membrane, inclosing a liquor a good deal resembling the white of an egg: in this may, even

* This history of the child in the womb is translated from M. Buffon, with some alterations.

then, be perceived, several small fibres, united together, which form the first rudiments of the embryo. Beside these, are seen another set of fibres, which soon after become the placenta, or that body by which the animal is supplied with nourishment.

Seven days after conception, we can readily distinguish, by the eye, the first lineaments of the child in the womb. However, they are as yet without form; showing, at the end of seven days, pretty much such an appearance as that of the chicken after four-and-twenty hours, being a small jelly-like mass, yet exhibiting the rudiments of the head: the trunk is barely visible; there likewise is to be discerned a small assemblage of fibres issuing from the body of the infant, which afterwards become the blood-vessels that convey nourishment from the placenta to the child, while inclosed in the womb.

Fifteen days after conception, the head becomes distinctly visible, and even the most prominent features of the visage begin to appear. The nose is a little elevated; there are two black specks in the place of eyes; and two little holes, where the ears are afterwards seen. The body of the embryo also is grown larger; and both above and below, are seen two little protuberances, which mark the places from whence the arms and thighs are to proceed. The length of the whole body at this time, is less than half an inch.

At the end of three weeks, the body has received very little increase; but the legs and feet, with the hands and arms, are become apparent. The growth of the arms is more speedy than that of

the legs; and the fingers are sooner separated than the toes. About this time, the internal parts are found, upon dissection, to become distinguishable. The places of the bones are marked by small thread-like substances, that are yet more fluid even than a jelly. Among them, the ribs are distinguishable, like threads also, disposed on each side of the spine: and even the fingers and toes scarcely exceed hairs in thickness.

In a month, the embryo is an inch long; the body is bent forward, a situation which it almost always assumes in the womb, either because a posture of this kind is the most easy, or because it takes up the least room. The human figure is now no longer doubtful: every part of the face is distinguishable; the body is sketched out; the bowels are to be distinguished as threads: the bones are still quite soft, but in some places beginning to assume a greater rigidity; the blood-vessels that go to the placenta, which, as was said, contributes to the child's nourishment, are plainly seen issuing from the navel (being therefore called the umbilical vessels), and going to spread themselves upon the placenta. According to Hippocrates, the male embryo developes sooner than the female: he adds, that, at the end of thirty days, the parts of the body of the male are distinguishable; while those of the female are not equally so till ten days after.

In six weeks, the embryo is grown two inches long; the human figure begins to grow every day more perfect; the head being still much larger, in proportion to the rest of the body; and the motion of the heart is perceived almost by the eye. It has been seen to beat in an embryo of fifty days

old, a long time after it had been taken out of the womb.

In two months, the embryo is more than two inches in length. The ossification is perceivable in the arms and thighs, and in the point of the chin, the under jaw being greatly advanced before the upper. These parts, however, may as yet be considered as bony points, rather than as bones. The umbilical vessels, which before went side by side, are now begun to be twisted like a rope, one over the other, and go to join with the placenta, which as yet is but small.

In three months, the embryo is above three inches long, and weighs about three ounces. Hippocrates observes, that not till then the mother perceives the child's motion; and he adds, that in female children, the motion is not observable till the end of four months. However, this is no general rule, as there are women who assert, that they perceived themselves to be quick with child, as their expression is, at the end of two months, so that this quickness seems rather to arise from the proportion between the child's strength and the mother's sensibility, than from any determinate period of time. At all times, however, the child is equally alive; and, consequently, those juries of matrons that are to determine upon the pregnancy of criminals, should not inquire whether the woman be quick, but whether she be with child; if the latter be perceivable, the former follows of course.

Four months and a half after conception, the embryo is from six to seven inches long. All the parts are so augmented, that even their proportions

are now distinguishable. The very nails begin to appear upon the fingers and toes; and the stomach and intestines already begin to perform their functions of receiving and digesting. In the stomach is found a liquor similar to that in which the embryo floats; in one part of the intestines, a milky substance; and, in the other, an excrementitious. There is found also, a small quantity of bile in the gall-bladder; and some urine in its own proper receptacle. By this time, also, the posture of the embryo seems to be determined. The head is bent forward, so that the chin seems to rest upon its breast; the knees are raised up towards the head, and the legs bent backward, somewhat resembling the posture of those who sit on their haunches. Sometimes the knees are raised so high as to touch the cheeks, and the feet are crost over each other; the arms are laid upon the breast, while one of the hands, and often both, touch the visage; sometimes the hands are shut, and sometimes, also, the arms are found hanging down by the body. These are the most usual postures which the embryo assumes; but these it is frequently known to change; and it is owing to these alterations that the mother so frequently feels those twitches, which are usually attended with pain.

The embryo, thus situated, is furnished by Nature with all things proper for its support; and, as it increases in size, its nourishment also is found to increase with it. As soon as it first begins to grow in the womb, that receptacle, from being very small, grows larger; and, what is more surprising, thicker every day. The sides of a bladder, as we

know, the more they are distended the more they become thin. But here, the larger the womb grows the more it appears to thicken. Within this the embryo is still farther involved in two membranes, called the chorion and amnios; and floats in a thin transparent fluid, upon which it seems, in some measure, to subsist. However, the great storehouse, whence its chief nourishment is supplied, is called the placenta; a red substance somewhat resembling a sponge, that adheres to the inside of the womb, and communicates, by the umbilical vessels, with the embryo. These umbilical vessels, which consist of a vein and two arteries, issue from the navel of the child, and are branched out upon the placenta; where they, in fact, seem to form its substance; and, if I may so express it, to suck up their nourishment from the womb, and the fluids contained therein. The blood thus received from the womb, by the placenta, and communicated by the umbilical vein to the body of the embryo, is conveyed to the heart; where without ever passing into the lungs, as in the born infant, it takes a shorter course; for, entering the right auricle of the heart, instead of passing up into the pulmonary artery, it seems to break this partition, and goes directly through the body of the heart, by an opening called the foramen ovale, and from thence to the aorta, or great artery; by which it is driven into all parts of the body. Thus we see the placenta, in some measure, supplying the place of lungs; for, as the little animal can receive no air by inspiration, the lungs are therefore useless. But we see the placenta converting the fluid of the womb into blood, and sending it, by the

umbilical vein, to the heart; from whence it is dispatched by a quicker and shorter circulation through the whole frame.

In this manner the embryo reposes in the womb; supplied with that nourishment which is fitted to its necessities, and furnished with those organs that are adapted to its situation. As its sensations are but few, its wants are in the same proportion; and it is probable that a sleep, with scarce any intervals, marks the earliest period of human life. As the little creature, however, gathers strength and size, it seems to become more wakeful and uneasy; even in the womb it begins to feel the want of something it does not possess; a sensation that seems coeval with man's nature, and never leaves him till he dies. The embryo even then begins to struggle for a state more marked by pleasure and pain, and, from about the sixth month, begins to give the mother warning of the greater pain she is yet to endure. The continuation of pregnancy, in woman, is usually nine months; but there have been many instances when the child has lived that was born at seven; and some are found to continue pregnant a month above the usual time. When the appointed time approaches, the infant, that has for some months been giving painful proofs of its existence, now begins to increase its efforts for liberty. The head is applied downward, to the aperture of the womb, and by reiterated efforts it endeavours to extend the same: these endeavours produce the pain which all women in labour feel in some degree; those of strong constitutions the least, those most weakly the most severely; since we learn, that the

women of Africa always deliver themselves, and are well a few hours after; while those of Europe require assistance, and recover more slowly. Thus the infant, still continuing to push with its head forward, by the repetition of its endeavours, at last succeeds, and issues into life. The blood, which had hitherto passed through the heart, now takes a wider circuit; and the foramen ovale closes; the lungs, that had till this time been inactive, now first begin their functions; the air rushes in to distend them; and this produces the first sensation of pain, which the infant expresses by a shriek; so that the beginning of our lives, as well as the end, is marked with anguish.*

From comparing these accounts, we perceive that the most laboured generation is the most perfect; and that the animal which, in proportion to its bulk, takes the longest time for production, is always the most complete when finished. Of all others, man seems the slowest in coming into life, as he is the slowest in coming to perfection; other animals, of the same bulk, seldom remain in the womb above six months, while he continues nine; and even after his birth appears more than any other to have his state of imbecility prolonged.

We may observe also, that that generation is the most complete in which the fewest animals are produced: Nature, by attending to the production of one at a time, seems to exert all her efforts in bringing it to perfection; but, where this attention is divided, the animals so produced come into the world with partial advantages. In this man-

* Bonnet Contemplat. de la Nature, vol. i. p. 212.

ner twins are never, at least while infants, so large or so strong as those that come singly into the world; each having, in some measure, robbed the other of its right; as that support, which Nature meant for one, has been prodigally divided.

In this manner, as those animals are the best that are produced singly, so we find that the noblest animals are ever the least fruitful. These are seen usually to bring forth but one at a time, and to place all their attention upon that alone. On the other hand, all the oviparous kinds produce in amazing plenty; and even the lower tribes of viviparous animals increase in a seeming proportion to their minuteness and imperfection. Nature seems lavish of life in the lower orders of the creation; and, as if she meant them entirely for the use of the nobler races, she appears to have bestowed greater pains in multiplying the number than in completing the kind. In this manner, while the elephant and the horse bring forth but one at a time, the spider and the beetle are seen to produce a thousand: and even among the smaller quadrupeds, all the inferior kinds are extremely fertile; any one of these being found, in a very few months, to become the parent of a numerous progeny.

In this manner, therefore, the smallest animals multiply in the greatest proportion; and we have reason to thank Providence, that the most formidable animals are the least fruitful. Had the lion and the tiger the same degree of fecundity with the rabbit or the rat, all the arts of man would be unable to oppose these fierce invaders; and we

should soon perceive them become the tyrants of those who claim the lordship of the creation. But Heaven, in this respect, has wisely consulted the advantage of all. It has opposed to man only such enemies as he has art and strength to conquer; and, as large animals require proportional supplies, Nature was unwilling to give new life, where it, in some measure, denied the necessary means of subsistence.

In consequence of this pre-established order, the animals that are endowed with the most perfect methods of generation, and bring forth but one at a time, seldom begin to procreate till they have almost acquired their full growth. On the other hand, those which bring forth many, engender before they have arrived at half their natural size. The horse and the bull, come almost to perfection before they begin to generate; the hog and the rabbit, scarcely leave the teat before they become parents themselves. In whatever light, therefore, we consider this subject, we shall find that all creatures approach most to perfection, whose generation most nearly resembles that of man. The reptile produced from cutting, is but one degree above the vegetable. The animal produced from the egg, is a step higher in the scale of existence: that class of animals which are brought forth alive, are still more exalted. Of these, such as bring forth one at a time are the most complete; and foremost of these stands man, *the great master of all*, who seems to have united the perfections of all the rest in his formation.

CHAP. XXV.

The Infancy of Man.

WHEN we take a survey of the various classes of animals, and examine their strength, their beauty, or their structure, we shall find man to possess most of those advantages united, which the rest enjoy partially. Infinitely superior to all others in the powers of the understanding, he is also superior to them in the fitness and proportions of his form. He would, indeed, have been one of the most miserable beings upon earth, if with a sentient mind he was so formed as to be incapable of obeying its impulse: but Nature has otherwise provided; as with the most extensive intellects to command, she has furnished him with a body the best fitted for obedience.

In infancy,* however, that mind, and this body, form the most helpless union in all animated nature; and, if any thing can give us a picture of complete imbecility, it is a man when just come into the world. The infant just born, stands in need of all things, without the power of procuring any. The lower races of animals, upon being produced, are active, vigorous, and capable of self-support; but the infant is obliged to wait in helpless expectation, and its cries are its only aid to procure subsistence.

An infant just born may be said to come from one element into another; for, from the watery

* Buffon, vol. iv. p. 173.

fluid in which it was surrounded, it now immerges into air; and its first cries seem to imply how greatly it regrets the change. How much longer it could have continued in a state of almost total insensibility, in the womb, is impossible to tell; but it is very probable that it could remain there some hours more. In order to throw some light upon this subject, M. Buffon so placed a pregnant bitch as that her puppies were brought forth in warm water, in which he kept them above half an hour at a time. However, he saw no change in the animals, thus newly brought forth; they continued the whole time vigorous; and, during the whole time, it is very probable that the blood circulated through the same channels through which it passed while they continued in the womb.

Almost all animals have their eyes closed,* for some days after being brought into the world. The infant opens them the instant of its birth. However, it seems to keep them fixed and idle; they want that lustre which they acquire by degrees; and if they happen to move, it is rather an accidental gaze than an exertion of the act of seeing. The light alone seems to make the greatest impression upon them. The eyes of infants are sometimes found turned to the place where it is strongest; and the pupil is seen to dilate and diminish, as in grown persons, in proportion to the quantity it receives. But still, the infant is incapable of distinguishing objects; the sense of seeing, like the rest of the senses, requires a habit before it becomes any way serviceable. All the

* Buffon, vol. iv. p. 173.

senses must be compared with each other, and must be made to correct the defects of one another, before they can give just information. It is probable, therefore, that if the infant could express its own sensations, it would give a very extraordinary description of the illusions which it suffers from them. The sight might, perhaps, be represented as inverting objects, or multiplying them; the hearing, instead of conveying one uniform tone, might be said to bring up an interrupted succession of noises; and the touch apparently would divide one body into as many as there are fingers that grasped it. But all these errors are lost in one common confused idea of existence; and it is happy for the infant, that it then can make but very little use of its senses, when they could serve only to bring it false information.

If there be any distinct sensations, those of pain seem to be much more frequent and stronger than those of pleasure. The infant's cries are sufficient indications of the uneasinesses it must, at every interval, endure; while, in the beginning, it has got no external marks to testify its satisfactions. It is not till after forty days that it is seen to smile; and not till that time also the tears begin to appear, its former expressions of uneasiness being always without them. As to any other marks of the passions, the infant being as yet almost without them, it can express none of them in its visage; which, except in the act of crying and laughing, is fixed in a settled serenity. All the other parts of the body seem equally relaxed and feeble; its motions are uncertain, and its postures without

choice; it is unable to stand upright; its hams are yet bent, from the habit which it received from its position in the womb; it has not strength enough in its arms to stretch them forward, much less to grasp any thing with its hands; it rests just in the posture it is laid; and, if abandoned, must continue in the same position.

Nevertheless, though this be the description of infancy among mankind in general, there are countries and races, among whom infancy does not seem marked with such utter imbecility, but where the children, not long after they are born, appear possessed of a greater share of self-support. The children of Negroes have a surprising degree of this premature industry: they are able to walk at two months; or, at least, to move from one place to another: they also hang to the mother's back without any assistance, and seize the breast over her shoulder, continuing in this posture till she thinks proper to lay them down. This is very different in the children of our countries, that seldom are able to walk under a twelvemonth.

The skin of children newly brought forth is always red, proceeding from its transparency, by which the blood beneath appears more conspicuous. Some say that this redness is greatest in those children that are afterwards about to have the finest complexions; and it appears reasonable that it should be so, since the thinnest skins are always the fairest. The size of a new-born infant is generally about twenty inches, and its weight about twelve pounds. The head is large, and all the members delicate, soft, and puffy. These appearances alter with its age; as it grows

older, the head becomes less in proportion to the rest of the body; the flesh hardens; the bones that before birth grew very thick in proportion, now lengthen by degrees, and the human figure more and more acquires its due dimensions. In such children, however, as are but feeble or sickly, the head always continues too big for the body; the heads of dwarfs being extremely large in proportion.

Infants, when newly born, pass most of their time in sleeping, and awake with crying, excited either by sensations of pain, or of hunger. Man, when come to maturity, but rarely feels the want of food, as eating twice or thrice in the four-and-twenty hours, is known to suffice the most voracious: but the infant may be considered as a little glutton, whose only pleasure consists in its appetite; and this, except when it sleeps, it is never easy without satisfying. Thus Nature has adapted different desires to the different periods of life; each as it seems most necessary for human support or succession. While the animal is yet forming, hunger excites it to that supply which is necessary for its growth; when it is completely formed, a different appetite takes place, that incites it to communicate existence. These two desires take up the whole attention at different periods, but are very seldom found to prevail strongly together in the same age; one pleasure ever serving to repress the other: and, if we find a person of full age, placing a principal part of his happiness in the nature and quantity of his food, we have strong reasons to suspect, that with respect to his other

appetites, he still retains a part of the imbecility of his childhood.

It is extraordinary, however, that infants, who are thus more voracious than grown persons, are nevertheless more capable of sustaining hunger. We have several instances, in accidental cases of famine, in which the child has been known to survive the parent; and seen clinging to the breast of its dead mother. Their little bodies also are more patient of cold; and we have similar instances of the mother's perishing in the snow, while the infant has been found alive beside her. However, if we examine the internal structure of infants, we shall find an obvious reason for both these advantages. Their blood-vessels are known to be much larger than in adults; and their nerves much thicker and softer: thus, being furnished with a more copious quantity of juices, both of the nervous and sanguinary kinds, the infant finds a temporary sustenance in this superfluity, and does not expire till both are exhausted. The circulation also being larger and quicker, supplies it with proportionable warmth, so that it is more capable of resisting the accidental rigours of the weather.*

[* Under circumstances like these, it is probable, that notwithstanding all nourishment was taken from the mother, the infant received, for some time, its natural supplies, though diminished in quantity: and while the mother was perishing with cold and exhaustion, maternal tenderness would take care to supply the infant with such warmth as clothing and pressure to her living body could administer. The blood of the infant moreover, being principally arterial, its greater degree of oxygenation would preserve respiration and life longer than in adults, under similar abstraction of necessary stimulants.]

The first nourishment of infants is well known to be the mother's milk; and, what is remarkable, the infant has milk in its own breasts, which may be squeezed out by compression: this nourishment becomes less grateful as the child gathers strength; and perhaps, also, more unwholesome. However, in cold countries, which are unfavourable to propagation, and where the female has seldom above three or four children at the most, during her life, she continues to suckle the child for four or five years together. In this manner the mothers of Canada and Greenland are often seen suckling two or three children, of different ages, at a time.

The life of infants is very precarious, till the age of three or four, from which time it becomes more secure; and when a child arrives at its seventh year, it is then considered as a more certain life, as M. Buffon asserts, than at any other age whatever. It appears, from Simson's Tables, that of a certain number of children born at the same time, a fourth part are found dead at the end of the first year; more than one third at the end of the second; and, at least, half, at the end of the third: so that those who live to be above three years old, are indulged a longer term than half the rest of their fellow-creatures. Nevertheless, life, at that period, may be considered as mere animal existence; and rather a preparation for, than an enjoyment of those satisfactions, both of mind and body, that make life of real value: and hence it is more natural for mankind to deplore a fellow-creature, cut off in the bloom of life, than one dying in early infancy. The one, by living up to

youth, and thus wading through the disadvantageous parts of existence, seems to have earned a short continuance of its enjoyments; the infant, on the contrary, has served but a short apprenticeship to pain; and, when taken away, may be considered as rescued from a long continuance of misery.

There is something very remarkable in the growth of the human body.* The embryo in the womb continues to increase still more and more, till it is born. On the other hand, the child's growth is less every year till the time of puberty, when it seems to start up of a sudden. Thus, for instance, the embryo, which is an inch long, in the first month, grows but one inch and a quarter in the second; it then grows one and a half in the third; two and a half in the fourth; and in this manner it keeps increasing, till, in the last month of its continuance, it is actually found to grow four inches; and, in the whole, about eighteen inches long. But it is otherwise with the child when born: if we suppose it eighteen inches at that time, it grows, in the first year, six or seven inches; in the second year, it grows but four inches; in the third year about three; and so on, at the rate of about an inch and a half, or two inches, each year, till the time of puberty, when Nature seems to make one great last effort, to complete her work, and unfold the whole animal machine.

The growth of the mind in children seems to correspond with that of the body. The comparative progress of the understanding is greater in infants than in children of three or four years old.

* M. Buffon, vol. iv. p. 173.

If we only reflect a moment on the amazing acquisitions that an infant makes in the first and second years of life, we shall have much cause for wonder. Being sent into a world where every thing is new and unknown, the first months of life are spent in a kind of torpid amazement; an attention distracted by the multiplicity of objects that press to be known. The first labour, therefore, of the little learner is, to correct the illusions of the senses, to distinguish one object from another, and to exert the memory, so as to know them again. In this manner a child of a year old has already made a thousand experiments; all which it has properly ranged, and distinctly remembers. Light, heat, fire, sweets, and bitters, sounds soft or terrible, are all distinguished at the end of a very few months. Besides this, every person the child knows, every individual object it becomes fond of, its rattles, or its bells, may be all considered as so many new lessons to the young mind, with which it has not become acquainted, without repeated exertions of the understanding. At this period of life, the knowledge of every individual object cannot be acquired without the same effort which, when grown up, is employed upon the most abstract idea: every thing the child hears or sees, all the marks and characters of nature, are as much unknown, and require the same attention to attain, as if the reader were set to understand the characters of an Ethiopic manuscript: and yet, we see in how short a time the little student begins to understand them all, and to give evident marks of early industry.

It is very amusing to pursue the young mind,

while employed in its first attainments. At about a year old, the same necessities that first engaged its faculties, increase, as its acquaintance with nature enlarges. Its studies, therefore, if I may use the expression, are no way relaxed; for, having experienced what gave pleasure at one time, it desires a repetition of it from the same object; and, in order to obtain this, that object must be pointed out: here, therefore, a new necessity arises, which, very often, neither its little arts nor importunities can remove; so that the child is at last obliged to set about naming the objects it desires to possess or avoid. In beginning to speak, which is usually about a year old, children find a thousand difficulties. It is not without repeated trials that they come to pronounce any one of the letters; nor without an effort of the memory, that they can retain them. For this reason, we frequently see them attempting a sound which they had learned, but forgot: and when they have failed, I have often seen their attempt attended with apparent confusion. The letters soonest learned, are those which are most easily formed; thus A and B require an obvious disposition of the organs, and their pronunciation is consequently soon attained. Z and R, which require a more complicated position, are learned with greater difficulty. And this may, perhaps, be the reason why the children in some countries speak sooner than in others; for the letters mostly occurring in the language of one country, being such as are of easy pronunciation, that language is of course more easily attained. In this manner the children of the Italians are said to speak sooner than those of the Germans; the

language of the one being smooth and open; that of the other crowded with consonants, and extremely guttural.

But be this as it will, in all countries children are found able to express the greatest part of their wants by the time they arrive at two years old; and from the moment the necessity of learning new words ceases, they relax their industry. It is then that the mind, like the body, seems every year to make slow advances; and, in order to spur up attention, many systems of education have been contrived.

Almost every philosopher who has written on the education of children, has been willing to point out a method of his own, chiefly professing to advance the health and improve the intellects at the same time. These are usually found to begin with finding nothing right in the common practice; and by urging a total reformation. In consequence of this, nothing can be more wild or imaginary than their various systems of improvement. Some will have the children every day plunged in cold water, in order to strengthen their bodies; they will have them converse with the servants in nothing but the Latin language, in order to strengthen their minds; every hour of the day must be appointed for its own studies, and the child must learn to make these very studies an amusement; till about the age of ten or eleven it becomes a prodigy of premature improvement. Quite opposite to this, we have others, whom the courtesy of mankind also calls philosophers: and they will have the child learn nothing till the age of ten or eleven, at which the former has attained so much perfection;

with them the mind is to be kept empty, until it has a proper distinction of some metaphysical ideas about truth; and the promising pupil is debarred the use of even his own faculties, lest they should conduct him into prejudice and error. In this manner, some men, whom fashion has celebrated for profound and fine thinkers, have given their hazarded and untried conjectures, upon one of the most important subjects in the world, and the most interesting to humanity. When men speculate at liberty upon innate ideas, or the abstracted distinctions between will and power, they may be permitted to enjoy their systems at pleasure, as they are harmless, although they may be wrong; but when they allege that children are to be every day plunged in cold water, and, whatever be their constitutions, indiscriminately inured to cold and moisture; that they are to be kept wet in the feet, to prevent their catching cold; and never to be corrected when young, for fear of breaking their spirits when old; these are such noxious errors, that all reasonable men should endeavour to oppose them. Many have been the children whom these opinions, begun in speculation, have injured or destroyed in practice; and I have seen many a little philosophical martyr, whom I wished, but was unable to relieve.

If any system be therefore necessary, it is one that would serve to show a very plain point; that very little system is necessary. The natural and common course of education is in every respect the best: I mean that in which the child is permitted to play among its little equals, from whose similar instructions it often gains the most useful stores of

knowledge. A child is not idle because it is playing about the fields, or pursuing a butterfly; it is all this time storing its mind with objects, upon the nature, the properties, and the relations of which future curiosity may speculate.

I have ever found it a vain task to try to make a child's learning its amusement; nor do I see what good end it would answer were it actually attained. The child, as was said, ought to have its share of play, and it will be benefited thereby; and for every reason also it ought to have its share of labour. The mind, by early labour, will be thus accustomed to fatigues and subordination; and whatever be the person's future employment in life, he will be better fitted to endure it: he will be thus enabled to support the drudgeries of office with content; or to fill up the vacancies of life with variety. The child, therefore, should by times be put to its duty, and be taught to know, that the task is to be done, or the punishment to be endured. I do not object against alluring it to duty by reward; but we well know, that the mind will be more strongly stimulated by pain; and both may, upon some occasions, take their turn to operate. In this manner, a child, by playing with its equals abroad, and labouring with them at school, will acquire more health and knowledge than by being bred up under the wing of any speculative system-maker; and will be thus qualified for a life of activity and obedience. It is true, indeed, that when educated in this manner, the boy may not be so seemingly sensible and forward as one bred up under solitary instruction; and, perhaps, this early forwardness is more engaging than useful. It is well known, that many

of those children who have been such prodigies of literature before ten, have not made an adequate progress to twenty. It should seem, that they only began learning manly things before their time; and, while others were busied in picking up that knowledge adapted to their age and curiosity, these were forced upon subjects unsuited to their years; and, upon that account alone, appearing extraordinary. The stock of knowledge in both may be equal; but with this difference, that each is yet to learn what the other knows.

But whatever may have been the acquisitions of children at ten or twelve, their greatest and most rapid progress is made when they arrive near the age of puberty. It is then that all the powers of nature seem at work in strengthening the mind, and completing the body: the youth acquires courage, and the virgin modesty; the mind, with new sensations, assumes new powers; it conceives with greater force, and remembers with greater tenacity. About this time, therefore, which is various in different countries, more is learned in one year than in any two of the preceding: and on this age, in particular, the greatest weight of instruction ought to be thrown.

CHAP. XXVI.

Of Puberty.

IT has been often said, that the season of youth is the season of pleasures: but this can only be true in savage countries, where but little preparation is

made for the perfection of human nature; and where the mind has but a very small part in the enjoyment. It is otherwise in those places where nature is carried to the highest pitch of refinement, in which this season of the greatest sensual delight is wisely made subservient to the succeeding and more rational one of manhood. Youth, with us, is but a scene of preparation; a drama, upon the right conduct of which all future happiness is to depend. The youth who follows his appetites, too soon seizes the cup, before it has received its best ingredients; and, by anticipating his pleasures, robs the remaining parts of life of their share; so that his eagerness only produces a manhood of imbecility and an age of pain.

The time of puberty is different in various countries, and always more late in men than in women. In the warm countries of India, the women are marriageable at nine or ten, and the men at twelve or thirteen. It is also different in cities where the inhabitants lead a more soft, luxurious life, from the country where they work harder, and fare less delicately. Its symptoms are seldom alike in different persons; but it is usually known by a swelling of the breasts in one sex, and a roughness of the voice in the other. At this season also the women seem to acquire new beauty, while the men lose all that delicate effeminacy of countenance which they had when boys.

All countries, in proportion as they are civilized or barbarous, improve or degrade the nuptial satisfaction. In those miserable regions, where strength makes the only law, the stronger sex exerts its power, and becomes the tyrant over the weaker: while the

inhabitant of Negroland is indolently taking his pleasure in the fields, his wife is obliged to till the grounds, that serve for their mutual support. It is thus in all barbarous countries, where the men throw all the laborious duties of life upon the women; and, regardless of beauty, put the softer sex to those employments that must effectually destroy it.

But, in countries that are half barbarous, particularly wherever Mahometanism prevails, the men run into the very opposite extreme. Equally brutal with the former, they exert their tyranny over the weaker sex, and consider that half of the human creation as merely made to be subservient to the depraved desires of the other. The chief, and indeed the only aim of an Asiatic, is to be possessed of many women; and to be able to furnish a seraglio, is the only tendency of his ambition. As the savage was totally regardless of beauty, he, on the contrary, prizes it too highly; he excludes the person who is possessed of such personal attractions from any share in the duties or employments of life; and, as if willing to engross all beauty to himself, increases the number of his captives in proportion to the progress of his fortune. In this manner he vainly expects to augment his satisfactions, by seeking from many, that happiness which he ought to look for in the society of one alone. He lives a gloomy tyrant, amidst wretches of his own making; he feels none of those endearments which spring from affection, none of those delicacies which arise from knowledge. His mistresses, being shut out from the world, and totally ignorant of all that passes there, have no arts to entertain

his mind, or calm his anxieties; the day passes with them in sullen silence, or languid repose; appetite can furnish but few opportunities of varying the scene; and all that falls beyond it must be irksome expectation.

From this avarice of women, if I may be allowed to express it so, has proceeded that jealousy and suspicion which ever attends the miser; hence those low and barbarous methods of keeping the women of those countries guarded, and of making, and procuring eunuchs to attend them. These unhappy creatures are of two kinds, the white and the black. The white are generally made in the country where they reside, being but partly deprived of the marks of virility; the black are generally brought from the interior parts of Africa, and are made entirely bare. These are chiefly chosen for their deformity: the thicker the lips, the flatter the nose, and the more black the teeth, the more valuable the eunuch; so that the vile jealousy of mankind here inverts the order of Nature; and the poor wretch finds himself valued in proportion to his deficiencies. In Italy, where this barbarous custom is still retained, and eunuchs are made, in order to improve the voice, the laws are severely aimed against such practice; so that, being entirely prohibited, none but the poorest and most abandoned of the people still secretly practise it upon their children. Of those served in this manner, not one in ten is found to become a singer; but such is the luxurious folly of the times, that the success of one amply compensates for the failure of the rest. It is very difficult to account for the alterations which castration makes in the voice, and the other parts of the

body. The eunuch is shaped differently from others. His legs are of an equal thickness above and below; his knees weak: his shoulders narrow; and his beard thin and downy. In this manner his person is rendered more deformed; but his desires, as I am told, still continue the same; and actually, in Asia, some of them are found to have their seraglios, as well as their masters. Even in our country, we have an instance of a very fine woman's being married to one of them, whose appearance was the most unpromising: and, what is more extraordinary still, I am told, that this couple continue perfectly happy in each other's society.

The mere necessities of life seem the only aim of the savage; the sensual pleasures are the only study of the semi-barbarian; but the refinement of sensuality, by reason, is the boast of real politeness. Among the merely barbarous nations, such as the natives of Madagascar, or the inhabitants of Congo, nothing is desired so ardently as to prostitute their wives, or daughters, to strangers, for the most trifling advantages; they will account it a dishonour not to be among the foremost who are thus received into favour; on the other hand, the Mahometan keeps his wife faithful, by confining her person; and would instantly put her to death, if he but suspected her chastity. With the politer inhabitants of Europe both these barbarous extremes are avoided; the woman's person is left free, and no constraint is imposed but upon her affections. The passion of love, which may be considered as the nice conduct of ruder desire, is only known, and practised in this part of the world; so that what other nations guard as their right, the

more delicate European is contented to ask as a favour. In this manner, the concurrence of mutual appetite contributes to increase mutual satisfaction; and the power on one side of refusing, makes every blessing more grateful when obtained by the other. In barbarous countries, woman is considered merely as an useful slave; in such as are somewhat more refined, she is regarded as a desirable toy; in countries entirely polished, she enjoys juster privileges; the wife being considered as an useful friend, and an agreeable mistress. Her mind is still more prized than her person; and without the improvement of both, she can never expect to become truly agreeable; for her good sense alone can preserve what she has gained by her beauty.

Female beauty, as was said, is always seen to improve about the age of puberty; but if we should attempt to define in what this beauty consists, or what constitutes its perfection, we should find nothing more difficult to determine. Every country has its peculiar way of thinking, in this respect; and even the same country thinks differently, at different times. The ancients had a very different taste from what prevails at present. The eye-brows joining in the middle was considered as a very peculiar grace, by Tibullus, in the enumeration of the charms of his mistress. Narrow foreheads were approved of, and scarcely any of the Roman ladies that are celebrated for their other perfections, but are also praised for the redness of their hair. The nose also of the Grecian Venus was such as would appear at present an actual deformity; as it fell in a straight line from the forehead, without the smallest

sinking between the eyes; without which we never see a face at present.

Among the moderns, every country seems to have peculiar ideas of beauty.* The Persians admire large eye-brows, joining in the middle; the edges and corners of the eyes are tinctured with black, and the size of the head is increased by a great variety of bandages, formed into a turban. In some parts of India, black teeth and white hair are desired with ardour; and one of the principal employments of the women of Thibet, is to redden the teeth with herbs, and to make their hair white by a certain preparation. The passion for coloured teeth obtains also in China and Japan; where, to complete their idea of beauty, the object of desire must have little eyes, nearly closed, feet extremely small, and a waist far from being shapely. There are some nations of the American Indians, that flatten the heads of their children, by keeping them, while young, squeezed between two boards, so as to make the visage much larger than it would naturally be. Others flatten the head at top; and others make it as round as they possibly can. The inhabitants along the western coasts of Africa have a very extraordinary taste for beauty. A flat nose, thick lips, and a jet black complexion, are there the most indulgent gifts of Nature. Such, indeed, they are all, in some degree, found to possess. However, they take care, by art, to increase the natural deformities, as they should seem to us; and they have many additional methods of render-

* M. Buffon.

ing their persons still more frightfully pleasing. The whole body and visage is often scarred with a variety of monstrous figures; which is not done without great pain, and repeated incision; and even sometimes parts of the body are cut away. But it would be endless to remark the various arts which caprice, or custom, has employed to distort and disfigure the body, in order to render it more pleasing: in fact, every nation, how barbarous soever, seems unsatisfied with the human figure, as Nature has left it, and has its peculiar arts of heightening beauty. Painting, powdering, cutting, boring the nose, and the ears, lengthening the one, and depressing the other, are arts practised in many countries; and, in some degree, admired in all. These arts might have been at first introduced to hide epidemic deformities; custom, by degrees, reconciles them to the view; till, from looking upon them with indifference, the eye at length begins to gaze with pleasure.

CHAP. XXVII.

Of the Age of Manhood.

THE human body attains to its full height during the age of puberty; or, at least, a short time

* This chapter is translated from M. Buffon, whose description is very excellent. Whatever I have added, is marked by inverted commas, "thus." And in whatever trifling points I have differed, the notes will serve to show.

after. Some young people are found to cease growing at fourteen or fifteen, others continue their growth till two or three and twenty. During this period they are all of a slender make: their thighs and legs small, and the muscular parts are yet unfilled. But, by degrees, the fleshy fibres augment; the muscles swell, and assume their figure; the limbs become proportioned, and rounder; and before the age of thirty, the body, in men, has acquired the most perfect symmetry. In women, the body arrives at perfection much sooner, as they arrive at the age of maturity more early; the muscles, and all the other parts being weaker, less compact, and solid, than those of man, they require less time in coming to perfection; and, as they are less in size, that size is sooner completed. Hence the persons of women are found to be as complete at twenty, as those of men are found to be at thirty.

The body of a well-shaped man ought to be square; the muscles should be expressed with boldness, and the lines of the face strongly marked. In the woman, all the muscles should be rounder, the lines softer, and the features more delicate. Strength and majesty belong to the man, grace and softness are the peculiar embellishments of the other sex. In both, every part of their form declares their sovereignty over other creatures. Man supports his body erect; his attitude is that of command; and his face, which is turned towards the heavens, displays the dignity of his station. The image of his soul is painted in his visage; and the excellence of his nature penetrates through the material form in which it is enclosed. His majestic port, his sedate and resolute step, announce the

nobleness of his rank. He touches the earth only with his extremity; and beholds it as if at a disdainful distance. His arms are not given him, as to other creatures, for pillars of support; nor does he lose, by rendering them callous against the ground, that delicacy of touch which furnishes him with so many of his enjoyments. His hands are made for very different purposes; to second every intention of his will, and to perfect the gifts of Nature.

When the soul is at rest, all the features of the visage seem settled in a state of profound tranquillity. Their proportion, their union, and their harmony, seem to mark the sweet serenity of the mind, and give a true information of what passes within. But, when the soul is excited, the human visage becomes a living picture; where the passions are expressed with as much delicacy as energy, where every motion is designed by some correspondent feature, where every impression anticipates the will, and betrays those hidden agitations, that he would often wish to conceal.

It is particularly in the eyes that the passions are painted; and in which we may most readily discover their beginning. The eye seems to belong to the soul more than any other organ; it seems to participate of all its emotions; as well the most soft and tender, as the most tumultuous and forceful. It not only receives, but transmits them by sympathy: the observing eye of one catches the secret fire from another; and the passion thus often becomes general.

Such persons as are short-sighted labour under a particular disadvantage in this respect. They

are, in a manner, entirely cut off from the language of the eyes; and this gives an air of stupidity to the face, which often produces very unfavourable prepossessions. However intelligent we find such persons to be, we can scarcely be brought back from our first prejudice, and often continue in the first erroneous opinion. In this manner we are too much induced to judge of men by their physiognomy; and having, perhaps, at first, caught up our judgments prematurely, they mechanically influence us all our lives after. This extends even to the very colour, or the cut of people's clothes; and we should, for this reason, be careful, even in such trifling particulars, since they go to make up a part of the total judgment which those we converse with may form to our advantage.

The vivacity, or the languid motion of the eyes, give the strongest marks to physiognomy; and their colour contributes still more to enforce the expression. The different colours of the eye are the dark hazle, the light hazle, the green, the blue, and grey, the whitish grey, "and also the red." These different colours arise from the different colours of the little muscles that serve to contract the pupil; "and they are very often found to change colour with disorder and with age."

The most ordinary colours are the hazle and the blue, and very often both these colours are found in the eyes of the same person. Those eyes which are called black are only of the dark hazle, which may be easily seen upon closer inspection; however, those eyes are reckoned the most beautiful where the shade is the deepest; and either in these, or the blue eyes, the fire, which gives its finest

expression to the eye, is more distinguishable in proportion to the darkness of the tint. For this reason, the black eyes, as they are called, have the greatest vivacity; but, probably, the blue have the most powerful effect in beauty, as they reflect a greater variety of lights, being composed of more various colours.

This variety, which is found in the colour of the eyes, is peculiar to man, and one or two other kinds of animals; but, in general, the colour in any one individual is the same in all the rest. The eyes of oxen are brown; those of sheep, of a water-colour; those of goats are grey; "and it may also be, in general, remarked, that the eyes of most white animals are red; thus the rabbit, the ferret, and, even in the human race, the white Moor, all have their eyes of a red colour."

Although the eye, when put into motion, seems to be drawn on one side; yet it only moves round the centre; by which its coloured part moves nearer, or farther from the angle of the eye-lids, or is elevated or depressed. The distance between the eyes is less in man than in any other animal; and in some of them it is so great, that it is impossible that they should ever view the same object with both eyes at once, unless it be very far off. "This, however, in them, is rather an advantage than an inconvenience; as they are thus able to watch round them, and guard against the dangers of their precarious situation."

Next to the eyes, the features, which most give a character to the face, are the eye-brows; which being, in some measure, more apparent than the

other features, are most readily distinguished at a distance. "Le Brun, in giving a painter directions, with regard to the passions, places the principal expression of the face in the eye-brows. From their elevation and depression, most of the furious passions are characterized; and such as have this feature extremely moveable, are usually known to have an expressive face. By means of these we can imitate all the other passions, as they are raised or depressed at command; the rest of the features are generally fixed; or, when put into motion, they do not obey the will; the mouth and eyes, in an actor, for instance, may, by being violently distorted, give a very different expression from what he would intend; but the eye-brows can scarcely be exerted improperly; their being raised, denotes all those passions which pride or pleasure inspire; and their depression marks those which are the effects of contemplation and pain. Such who have this feature, therefore, most at command, are often found to excel as actors."

The eye-lashes have an effect, in giving expression to the eye, particularly when long and close; they soften its glances, and improve its sweetness. Man and apes are the only animals that have eye-lashes both upon the upper and lower lids; all other animals want them on the lid below.

The eye-lids serve to guard the ball of the eye, and to furnish it with a proper moisture. The upper lid rises and falls; the lower has scarce any motion; and although their being moved depends on the will, yet it often happens that the will is unable to keep them open, when sleep or fatigue

oppresses the mind. In birds, and amphibious quadrupeds, the lower lid alone has motion; fishes and insects have no eye-lids whatsoever.

The forehead makes a large part of the face, and a part which chiefly contributes to its beauty. It ought to be justly proportioned; neither too round nor too flat; neither too narrow nor too low; and the hair should come thick upon its extremities. It is known to every body how much the hair tends to improve the face; and how much the being bald serves to take away from beauty. The highest part of the head is that which becomes bald the soonest, as well as that part which lies immediately above the temples. The hair under the temples, and at the back of the head, is very seldom known to fail, "and women are much less apt to become bald than men. M. Buffon seems to think they never become bald at all; but we have too many instances of the contrary among us, not to contradict very easily the assertion. Of all parts or appendages of the body, the hair is that which is found most different in different climates; and often not only contributes to mark the country, but also the disposition of the man. It is, in general, thickest where the constitution is strongest; and more glossy and beautiful where the health is most permanent. The ancients held the hair to be a sort of excrement, produced like the nails; the part next the root pushing out that immediately contiguous. But the moderns have found that every hair may be truly said to live, to receive nutriment, to fill and distend itself like the other parts of the body. The roots, they observe, do not turn grey sooner than the extremities, but

the whole hair changes colour at once; and we have many instances of persons who have grown grey in one night's time.* Each hair, if viewed with a microscope, is found to consist of five or six lesser ones, all wrapped up in one common covering; it appears knotted, like some sorts of grass, and sends forth branches at the joints. It is bulbous at the root, by which it imbibes its moisture from the body, and it is split at the points; so that a single hair, at its end, resembles a brush. Whatever be the size or the shape of the pore through which the hair issues, it accommodates itself to the same; being either thick, as they are large; small, as they are less; round, triangular, and variously formed as the pores happen to be various. The hair takes its colour from the juices flowing through it; and it is found that this colour differs in different tribes and races of people. The Americans and the Asiatics have their hair black, thick, straight, and shining. The inhabitants of the torrid climates of Africa have it black, short, and woolly. The people of Scandinavia have it red, long, and curled; and those of our own, and the neighbouring countries, are found with hair of various colours. However, it is supposed by many, that every man resembles in his disposition the inhabitants of those countries whom he resembles in the colour and the nature of his hair; so that the black are said, like the Asiatics, to be grave and acute; the red, like the Gothic nations, to be choleric and bold. However this may be, the length and the strength of the hair is a general

* M. Buffon says that the hair begins to grow grey at the points, but the fact is otherwise.

mark of a good constitution; and, as that hair which is strongest is most commonly curled, so curled hair is generally regarded among us as a beauty. The Greeks, however, had a very different idea of beauty in this respect; and seem to have taken one of their peculiar national distinctions from the length and the straightness of the hair."

The nose is the most prominent feature in the face; but, as it has scarcely any motion, and that only in the strongest passions, it rather adds to the beauty than to the expression of the countenance. "However, I am told, by the skilful in this branch of knowledge, that wide nostrils add a great deal to the bold and resolute air of the countenance; and where they are narrow, though it may constitute beauty, it seldom improves expression." The form of the nose, and its advanced position, are peculiar to the human visage alone. Other animals, for the most part, have nostrils, with a partition between them; but none of them have an elevated nose. Apes themselves have scarcely any thing else of this feature but the nostrils; the rest of the feature lying flat upon the visage, and scarcely higher than the cheek bones. "Among all the tribes of the savage men also, the nose is very flat; and I have seen a Tartar who had scarcely any thing else but two holes through which to breathe."

The mouth and lips, next to the eyes, are found to have the greatest expression. The passions have great power over this part of the face; and the mouth marks its different degrees by its different forms. The organ of speech still more animates

this part, and gives it more life than any other feature in the countenance. The ruby colour of the lips, and the white enamel of the teeth, give it such a superiority over every other feature, that it seems to make the principal object of our regards. In fact, the whole attention is fixed upon the lips of the speaker; however rapid his discourse, however various the subject, the mouth takes correspondent situations; and deaf men have been often found to see the force of those reasonings which they could not hear, understanding every word as it was spoken.*

"The under jaw in man possesses a great variety of motions, while the upper has been thought, by many, to be quite immoveable.† However, that it moves in man, a very easy experiment will suffice to convince us. If we keep the head fixed, within any thing between our teeth, the edge of a table for instance, and then open our mouths, we shall find that both jaws recede from it at the

[* Professor Camper, in his dissertation on skulls, has drawn this excellent corollary. If a line be drawn longitudinally from the forehead to the mouth, and another transversely from the point of the ear to meet the other line, the head will be perfectly formed in proportion as these two lines approach to a right angle. The skull of the Grecian makes nearly a right angle; that of the European of colder climates is something less: the Jew, the savage, and the Hottentot, have their gradual approaches to an acute angle, in consequence of the greater or less protrusion of the bones of the mouth: the ape, the dog, and the swine, make a still more acute angle; till, at length, in the beaks of birds, the two lines nearly meet.]

† M. Buffon is of this opinion. He says, that the upper jaw is immoveable in all animals. However, the parrot is an obvious exception; and so is man himself, as shown above.

same time; the upper jaw rises, the lower falls, and the table remains untouched between them. The upper jaw has motion as well as the under; and, what is remarkable, it has its proper muscles behind the head, for thus raising and depressing it. Whenever, therefore, we eat, both jaws move at the same time, though very unequally; for the whole head moving with the upper jaw, of which it makes a part, its motions are thus less observable." In the human embryo, the under jaw is very much advanced before the upper. "In the adult, it hangs a good deal more backward: and those whose upper and under row of teeth are equally prominent, and strike directly against each other, are what the painters call under-hung; and they consider this as a great defect in beauty.* The under jaw in a Chinese face falls greatly more backward than with us; and, I am told, the difference is half an inch, when the mouth is shut naturally." In instances of the most violent passion, the under jaw has often an involuntary quivering motion; and often, also, a state of languor produces another, which is that of yawning. Every one knows how very sympathetic this kind of languid motion is; and that for one person to yawn, is sufficient to set all the rest of the company a yawning. A ridiculous instance of this was commonly practised upon the famous M'Laurin, one of the professors at Edinburgh. He was very subject to have his jaw dislocated; so that when he opened his mouth wider than ordinary, or when he yawned, he could not shut it again. In

* M. Buffon says, that both jaws, in a perfect face, should be on a level; but this is denied by the best painters.

the midst of his harangues, therefore, if any of his pupils began to be tired of his lecture, he had only to gape, or yawn, and the professor instantly caught the sympathetic affection; so that he thus continued to stand speechless, with his mouth wide open, till his servant, from the next room, was called in to set his jaw again." *

When the mind reflects with regret upon some good unattained or lost, it feels an internal emotion, which acting upon the diaphragm, and that upon the lungs, produces a sigh; this, when the mind is strongly affected, is repeated; sorrow succeeds these first emotions, and tears are often seen to follow; sobbing is the sigh still more invigorated; and lamentation or crying proceeds from the continuance of the plaintive tone of the voice, which seems to implore pity. "There is yet a silent agony, in which the mind appears to disdain all external help, and broods over its distresses with gloomy reserve. This is the most dangerous state of mind; accidents or friendship may lessen the louder kinds of grief; but all remedies for this must be had from within: and there, despair too often finds the most deadly enemy."

Laughter is a sound of the voice, interrupted and pursued for some continuance. The muscles of the belly, and the diaphragm, are employed in the slightest exertions; but those of the ribs are strongly agitated in the louder: and the head sometimes is thrown backward, in order to raise them with greater ease. The smile is often an in-

[* Since the publication of this work, the editor has been credibly informed, that the professor had not the defect here mentioned.]

dication of kindness and good-will: it is also often used as a mark of contempt and ridicule.

. Blushing proceeds from different passions; being produced by shame, anger, pride, and joy. Paleness is often also the effect of anger; and almost ever attendant on fright and fear. These alterations in the colour of the countenance are entirely involuntary; all the other expressions of the passions are, in some small degree, under control; but blushing and paleness betray our secret purposes; and we might as well attempt to stop them, as the circulation of the blood, by which they are caused.

The whole head, as well as the features of the face, takes peculiar attitudes from its passions: it bends forward, to express humility, shame, or sorrow; it is turned to one side in languor or in pity; it is thrown with the chin forward in arrogance and pride; erect in self-conceit and obstinacy; it is thrown backwards in astonishment; and combines its motion to the one side and the other, to express contempt, ridicule, anger, and resentment. "Painters, whose study leads to the contemplation of external forms, are much more adequate judges of these than any naturalist can be; and it is with these a general remark, that no one passion is regularly expressed on different countenances in the same manner; but that grief often sits upon the face like joy; and pride assumes the air of passion. It would be vain, therefore, in words, to express their general effect, since they are often as various as the countenances they sit upon; and in making this distinction nicely, lies all the skill of the physiognomist. In being able to distinguish

what part of the face is marked by nature, and what by the mind; what part has been originally formed, and what is made by habit, constitutes this science, upon which the ancients so much valued themselves, and which we at present so little regard. Some, however, of the most acute men among us, have paid great attention to this art; and, by long practice, have been able to give some character of every person whose face they examined. Montaigne is well known to have disliked those men who shut one eye in looking upon any object; and Fielding asserts, that he never knew a person with a steady glavering smile, but he found him a rogue. However, most of these observations, tending to a discovery of the mind by the face, are merely capricious; and Nature has kindly hid our hearts from each other, to keep us in good humour with our fellow-creatures."

The parts of the head which give the least expression to the face, are the ears; and they are generally found hidden under the hair. These, which are immoveable, and make so small an appearance in man, are very distinguishing features in quadrupeds. They serve in them as the principal marks of the passions; the ears discover their joys or their terrors, with tolerable precision; and denote all their internal agitations. The smallest ears, in men, are said to be most beautiful; but the largest are found the best for hearing. There are some savage nations who bore their ears, and so draw that part down, that the tips of the ears are seen to rest upon their shoulders.

The strange variety of the different customs of men, appears still more extravagant in their man-

ner of wearing their beards. Some, and among others the Turks, cut the hair off their heads, and let their beards grow. The Europeans, on the contrary, shave their beards, and wear their hair. The Negroes shave their heads in figures at one time, in stars at another, in the manner of friars; and still more commonly in alternate stripes; and their little boys are shaved in the same manner. The Talapoins, of Siam, shave the heads and the eyebrows of such children as are committed to their care. Every nation seems to have entertained different prejudices, at different times, in favour of one part or another of the beard. Some have admired the hair upon the cheeks on each side, as we see with some low-bred men among ourselves, who want to be fine. Some like the hair lower down; some choose it curled; and others like it straight. "Some have cut it into a peak; and others shave all but the whisker. This particular part of the beard was highly prized among the Spaniards; till of late, a man without whiskers was considered as unfit for company; and where Nature had denied them, Art took care to supply the deficiency. We are told of a Spanish general who, when he borrowed a large sum of money from the Venetians, pawned his whisker, which he afterwards took proper care to release. Kingson assures us, that a considerable part of the religion of the Tartars consists in the management of their whiskers; and that they waged a long and bloody war with the Persians, declaring them infidels, merely because they would not give their whiskers the orthodox cut. The kings of Persia carried the care of their beards to a ridiculous excess, when they chose to wear

them matted with gold thread: and even the kings of France, of the first races, had them knotted and buttoned with gold. But of all nations, the Americans take the greatest pains in cutting their hair, and plucking their beards. The under part of the beard, and all but the whisker, they take care to pluck up by the roots, so that many have supposed them to have no hair naturally growing on that part: and even Linnæus has fallen into that mistake. Their hair is also cut into bands; and no small care employed in adjusting the whisker. In fact, we have a very wrong idea of savage finery; and are apt to suppose that, like the beasts of the forest, they rise, and are dressed with a shake: but the reverse is true; for no birth-night beauty takes more time or pains in the adorning her person than they. I remember, when the Cherokee kings were over here, that I have waited for three hours during the time they were dressing. They never would venture to make their appearance till they had gone through the tedious ceremonies of the toilet; they had their boxes of oil and ochre, their fat, and their perfumes, like the most effeminate beau, and generally took up four hours in dressing, before they considered themselves as fit to be seen. We must not, therefore, consider a delicacy in point of dress, as a mark of refinement, since savages are much more difficult in this particular, than the most fashionable or tawdry European. The more barbarous the people, the fonder of finery. In Europe, the lustre of jewels, and the splendour of the most brilliant colours, are generally given up to women, or to the weakest part of the other sex, who are willing to be comtemp-

tibly fine: but in Asia, these trifling fineries are eagerly sought after by every condition of men; and, as the proverb has it, we find the richest jewels in an Æthiop's ear. The passion for glittering ornaments, is still stronger among the absolute barbarians, who often exchange their whole stock of provisions, and whatever else they happen to be possessed of, with our seamen, for a glass bead, or a looking-glass."

Although fashions have arisen in different countries from fancy and caprice, these, when they become general, deserve examination. Mankind have always considered it as a matter of moment, and they will ever continue desirous of drawing the attention of each other, by such ornaments as mark the riches, the power, or the courage of the wearer. The value of those shining stones which have at all times been considered as precious ornaments, is entirely founded upon their scarceness or their brilliancy. It is the same likewise with respect to those shining metals, the weight of which is so little regarded, when spread over our clothes. These ornaments are rather designed to draw the attention of others, than to add to any enjoyments of our own; and few there are that these ornaments will not serve to dazzle, and who can coolly distinguish between the metal and the man.

All things rare and brilliant will, therefore, ever continue to be fashionable, while men derive greater advantage from opulence than virtue; while the means of appearing considerable are more easily acquired, than the title to be considered. The first

impression we generally make, arises from our dress; and this varies, in conformity to our inclinations, and the manner in which we desire to be considered. The modest man, or he who would wish to be thought so, desires to show the simplicity of his mind, by the plainness of his dress; the vain man, on the contrary, takes a pleasure in displaying his superiority, "and is willing to incur the spectator's dislike, so he does but excite his attention."

Another point of view which men have in dressing, is to increase the size of their figure; and to take up more room in the world than Nature seems to have allotted them. We desire to swell out our clothes by the stiffness of art, and raise our heels, while we add to the largeness of our heads. How bulky soever our dress may be, our vanities are still more bulky. The largeness of the doctor's wig arises from the same pride with the smallness of the beau's queue. Both want to have the size of their understanding measured by the size of their heads.

There are some modes that seem to have a more reasonable origin, which is to hide or to lessen the defects of Nature. To take men altogether, there are many more deformed and plain, than beautiful and shapely. The former, as being the most numerous, give law to fashion; and their laws are generally such as are made in their own favour. The women begin to colour their cheeks with red, when the natural roses are faded; and the younger are obliged to submit, though not compelled by the same necessity. In all parts of the

world, this custom prevails more or less; and powdering and frizzing the hair, though not so general, seems to have arisen from a similar control.

But leaving the draperies of the human picture, let us return to the figure, unadorned by art. Man's head, whether considered externally or internally, is differently formed from that of all other animals, the monkey-kind only excepted, in which there is a striking similitude. There are some differences, however, which we shall take notice of in another place. The bodies of all quadruped animals are covered with hair; but the head of man seems the part most adorned; and that more abundantly than in any other animal.

There is a very great variety in the teeth of all animals; some have them above and below; others have them in the under jaw only; in some they stand separate from each other; while in some they are continued and united. The palate of some fishes is nothing else but a bony plate studded with points, which perform the offices of teeth. All these substances, in every animal, derive their origin from the nerves; the substance of the nerves hardens by being exposed to the air; and the nerves that terminate in the mouth, being thus exposed, acquire a bony solidity. In this manner, the teeth and nails are formed in man; and in this manner, *also*, the beak, the hoofs, the horns, and the talons of other animals, are found to be produced.

The neck supports the head, and unites it to the body. This part is much more considerable in the generality of quadrupeds, than in man. But fishes, and other animals that want lungs similar to ours, have no neck whatsoever. Birds, in general, have

the neck longer than any other kind of animals: those of them, which have short claws, have also short necks; those, on the contrary, that have them long, are found to have the neck in proportion. "In men, there is a lump upon the wind-pipe, formed by the thyroid cartilage, which is not to be seen in women; an Arabian fable says that this is a part of the original apple, that has stuck in the man's throat by the way, but that the woman swallowed her part of it down."

The human breast is outwardly formed in a very different manner from that of other animals. It is larger in proportion to the size of the body; and none but man, and such animals as make use of their fore feet as hands, such as monkies, bats, and squirrels, and such quadrupeds as climb trees, are found to have those bones called the clavicles, or, as we usually term them, the collar-bones.* The breasts in women are larger than in men; however, they seem formed in the same manner; and, sometimes, milk is found in the breasts of men, as well as in those of women. Among animals, there is a great variety in this part of the body. The teats of some, as in the ape and the elephant, are like those of men, being but two, and placed on each side of the breast. The teats of the bear amount to four. The sheep has but two, placed between the hinder legs. Other animals, such as the bitch, and the sow, have them all along the belly; and, as they produce many young, they have a great many teats for their support. The

* M. Buffon says, that none but monkeys have them; but this is an oversight.

form also of the teats varies in different animals; and, in the same animal, at different ages. The bosom in females seems to unite all our ideas of beauty, where the outline is continually changing, and the gradations are soft and regular.

" The graceful fall of the shoulders, both in man and woman, constitute no small part of beauty. In apes, though otherwise made like us, the shoulders are high, and drawn up on each side towards the ears. In man they fall by a gentle declivity; and the more so, in proportion to the beauty of his form. In fact, being high-shouldered, is not without reason considered as a deformity, for we find very sickly persons are always so; and people, when dying, are ever seen with their shoulders drawn up in a surprising manner. The muscles that serve to raise the ribs, mostly rise near the shoulders: and the higher we raise the shoulders, we the more easily raise the ribs likewise. It happens, therefore, in the sickly and the dying, who do not breathe without labour, that to raise the ribs they are obliged to call in the assistance of the shoulders; and thus their bodies assume, from habit, that form which they are so frequently obliged to assume. Women with child also are usually seen to be high-shouldered; for the weight of the inferior parts drawing down the ribs, they are obliged to use every effort to elevate them, and thus they raise the shoulders of course. During pregnancy, also, the shape, not only of the shoulders, but also of the breast, and even the features of the face, are greatly altered: for the whole upper fore-part of the body is covered with a broad thin skin, called the myoides; which, being, at

that time, drawn down, it also draws down with it the skin, and, consequently, the features of the face. By these means the visage takes a particular form; the lower eye-lids, and the corners of the mouth, are drawn downwards; so that the eyes are enlarged and the mouth lengthened; and women, in these circumstances, are said, by the midwives, to be all mouth and eyes."

The arms of men but very little resemble the fore feet of quadrupeds, and much less the wings of birds. The ape is the only animal that is possessed of hands and arms; but these are much more rudely fashioned, and with less exact proportion than in men; "the thumb not being so well opposed to the rest of the fingers, in their hands, as in ours."

The form of the back is not much different in man from that of other quadruped animals, only that the reins are more muscular in him and stronger. The buttock, however, in man, is different from that of all other animals whatsoever. What goes by that name, in other creatures, is only the upper part of the thigh: man being the only animal that supports himself perfectly erect, the largeness of this part is owing to the peculiarity of his position.

Man's feet also are different from those of all other animals, those even of apes not excepted. The foot of the ape is rather a kind of awkward hand; its toes, or rather fingers, are long, and that of the middle longest of all. This foot also wants the heel, as in man; the sole is narrower, and less adapted to maintain the equilibrium of the body in walking, dancing, or running.

The nails are less in man than in any other animal. If they were much longer than the extremities of the fingers, they would rather be prejudicial than serviceable, and obstruct the management of the hand. Such savages as let them grow long, make use of them in flaying animals, in tearing their flesh, and such like purposes; however, though their nails are considerably larger than ours, they are by no means to be compared to the hoofs or the claws of other animals. "They may sometimes be seen longer, indeed, than the claws of any animal whatsoever; as we learn that the nails of some of the learned men in China are longer than their fingers. But these want that solidity which might give force to their exertions; and could never, in a state of nature, have served them for annoyance or defence."

There is little known exactly with regard to the proportion of the human figure; and the beauty of the best statues is better conceived by observing than by measuring them. The statues of antiquity, which were at first copied after the human form, are now become the models of it; nor is there one man found whose person approaches to those inimitable performances, that have thus, in one figure, united the perfections of many. It is sufficient to say that, from being at first models, they are now become originals; and are used to correct the deviations in that form from whence they were taken. I will not, however, pretend to give the proportions of the human body, as taken from these, there being nothing more arbitrary, and which good painters themselves so much contemn. Some, for instance, who have studied after

these, divide the body into ten times the length of the face, and others into eight. Some pretend to tell us that there is a similitude of proportion in different parts of the body. Thus, that the hand is the length of the face; the thumb the length of the nose; the space between the eyes is the breadth of an eye; that the breadth of the thigh, at thickest, is double that of the thickest part of the leg, and treble the smallest; that the arms extended, are as long as the figure is high; that the legs and thighs are half the length of the figure. All this, however, is extremely arbitrary; and the excellence of a shape, or the beauty of a statue, results from the attitude and position of the whole, rather than any established measurements, begun without experience, and adopted by caprice. In general, it may be remarked that the proportions alter in every age, and are obviously different in the two sexes. In woman, the shoulders are narrower, and the neck proportionably longer than in men. The lips also are considerably larger, and the thighs much shorter than in men. These proportions, however, vary greatly at different ages. In infancy, the upper parts of the body are much larger than the lower; the legs and thighs do not constitute any thing like half the height of the whole figure: in proportion as the child increases in age, the inferior parts are found to lengthen; so that the body is not equally divided until it has acquired its full growth.

The size of men varies considerably. Men are said to be tall who are from five feet eight inches, to six feet high. The middle stature is from five feet five to five feet eight: and those are said to

be of small stature who fall under these measures. "However, it ought to be remarked, that the same person is always taller when he arises in the morning, than upon going to bed at night; and sometimes there is an inch difference; and I have seen more. Few persons are sensible of this remarkable variation; and, I am told, it was first perceived, in England, by a recruiting officer. He often found that those men whom he had enlisted for soldiers, and answered to the appointed standard at one time, fell short of it when they came to be measured before the colonel, at the head-quarters. This diminution in their size proceeded from the different times of the day, and the different states of the body, when they happened to be measured. If, as was said, they were measured in the morning, after the night's refreshment, they were found to be commonly half an inch, and very often a whole inch taller than if measured after the fatigues of the day; if they were measured when fresh, in the country, and before a long fatiguing march to the regiment, they were found to be an inch taller than when they arrived at their journey's end. All this is now well known among those who recruit for the army; and the reason of this difference of stature is obvious. Between all the joints of the back-bone, which is composed of several pieces, there is a glutinous liquor deposited, which serves, like oil in a machine, to give the parts an easy play upon each other. This lubricating liquor, or synovia, as the anatomists call it, is poured in during the season of repose, and is consumed by exercise and employment; so that in a body after hard labour, there is scarce any of it remain-

ing; but all the joints grow stiff, and their motion becomes hard and painful. It is from hence, therefore, that the body diminishes in stature. For this moisture being drained away from between the numerous joints of the back-bone, they lie closer upon each other; and their whole length is thus very sensibly diminished; but sleep, by restoring the fluid, again swells the spaces between the joints, and the whole is extended to its former dimensions.

"As the human body is thus often found to differ from itself in size, so it is found to differ in its weight also: and the same person, without any apparent cause, is found to be heavier at one time than another. If, after having eaten a hearty dinner, or having drunk hard, the person should find himself thus heavier, it would appear no way extraordinary; but the fact is, the body is very often found heavier some hours after eating a hearty meal, than immediately succeeding it. If, for instance, a person, fatigued by a day's hard labour, should eat a plentiful supper, and then get himself weighed upon going to bed; after sleeping soundly, if he is again weighed, he will find himself considerably heavier than before; and this difference is often found to amount to a pound, or sometimes to a pound and a half. From whence this adventitious weight is derived is not easy to conceive; the body during the whole night appears rather plentifully perspiring than imbibing any fluid, rather losing than gaining moisture: however, we have no reason to doubt but that either by the lungs, or, perhaps, by a peculiar set of pores, it is all this time inhaling a quantity of

fluid, which thus increases the weight of the whole body, upon being weighed the next morning." *

Although the human body is externally more delicate than any of the quadruped kind, it is, notwithstanding, extremely muscular; and, perhaps, for its size, stronger than that of any other animal. If we should offer to compare the strength of the lion with that of man, we should consider that the claws of this animal give us a false idea of its power; we ascribe to its force what is only the effects of its arms. Those which man has received from Nature are not offensive; happy had Art never furnished him with any more terrible than those which arm the paws of the lion!

But there is another manner † of comparing the strength of man with that of other animals; namely, by the weights which either can carry. We are assured that the porters of Constantinople carry burthens of nine hundred pounds weight: M. Desaguliers tells us of a man, who, by distributing weights in such a manner as that every part of his body bore its share, was thus able to raise a weight of two thousand pounds. A horse, which is about seven times our bulk, would be thus able to raise a weight of fourteen thousand pounds, if its strength were in the same proportion.‡ "But,

* From the experiment also, the learned may gather upon what a weak foundation the whole doctrine of Sanctorian perspiration is built; but this disquisition more properly belongs to medicine than natural history.

† M. Buffon calls it a better manner, but this is not the case.

‡ M. Buffon carries this subject no farther; and thus far, without explanation, it is erroneous.

the truth is, a horse will not carry upon its back above a weight of two or three hundred pounds; while a man, of confessedly inferior strength, is thus able to support two thousand. Whence comes this seeming superiority? The answer is obvious. Because the load upon man's shoulders, is placed to the greatest advantage; while, upon the horse's back, it is placed at the greatest disadvantage. Let us suppose, for a moment, the man standing as upright as possible, under the great load above mentioned. It is obvious that all the bones of his body may be compared to a pillar supporting a building, and that his muscles have scarce any share in this dangerous duty. However, they are not entirely inactive; as man, let him stand never so upright, will have some bending in different parts of his body. The muscles, therefore, give the bones some assistance, and that with the greatest possible advantage. In this manner, a man has been found to support two thousand weight; but may be capable of supporting a still greater. The manner in which this is done, is by strapping the load round the shoulders of the person who is to bear it, by a machine something like that by which milk-vessels or water-buckets are carried. The load being thus placed on a scaffold, on each side, contrived for that purpose, and the man standing erect in the midst, all parts of the scaffold, except that where the man stands, are made to sink; and thus the man maintaining his position, the load, whatever it is, becomes suspended, and the column of his bones may be fairly said to support it. If, however, he should but ever so little give way, he must inevit-

ably drop; and no power of his can raise the weights again. But the case is very different with regard to a load laid upon a horse. The column of the bones there lies a different way; and a weight of five hundred pounds, as I am told, would break the back of the strongest horse that could be found. The great force of a horse and other quadrupeds, is exerted when the load is in such a position as that the column of the bones can be properly applied; which is lengthwise. When, therefore, we are to estimate the comparative strength of a horse, we are not to try what he can carry, but what he can draw; and, in this case, his amazing superiority over man is easily discerned; for one horse can draw a load that ten men cannot move. And, in some cases, it happens that a draft horse draws the better for being somewhat loaded; for, as the peasants say, the load upon the back keeps him the better to the ground."

There is still another way of estimating human strength by the perseverance and agility of our motions. Men, who are exercised in running, outstrip horses; or at least hold their speed for a longer continuance. In a journey, also, a man will walk down a horse; and, after they have both continued to proceed for several days, the horse will be quite tired, and the man will be fresher than in the beginning. The king's messengers of Ispahan, who are runners by profession, go thirty-six leagues in fourteen hours. Travellers assure us that the Hottentots outstrip lions in the chase; and that the savages, who hunt the elk, pursue with such speed, that they at last tire down and take it. We are told many very surprising things

of the great swiftness of the savages, and of the long journeys they undertake, on foot, through the most craggy mountains, where there are no paths to direct, nor houses to entertain them. They are said to perform a journey of twelve hundred leagues in less than six weeks. "But, notwithstanding what travellers report of this matter, I have been assured, from many of our officers and soldiers, who compared their own swiftness with that of the native Americans, during the last war, that although the savages held out, and, as the phrase is, had better bottoms, yet, for a spurt, the Englishmen were more nimble and speedy."

Nevertheless, in general, civilized man is ignorant of his own powers; he is ignorant how much he loses by effeminacy; and what might be acquired by habit and exercise. Here and there, indeed, men are found among us of extraordinary strength; but that strength, for want of opportunity, is seldom called into exertion. "Among the ancients it was a quality of much greater use than at present; as in war the same man that had strength sufficient to carry the heaviest armour, had strength sufficient also to strike the most fatal blow. In this case, his strength was at once his protection and his power. We ought not to be surprised, therefore, when we hear of one man terrible to an army, and irresistible in his career, as we find some generals represented in ancient history. But we may be very certain that this prowess was exaggerated by flattery, and exalted by terror. An age of ignorance is ever an age of wonder. At such times, mankind, having no just ideas of the human powers, are willing rather to

generally continue on the tops of trees, like our wild cats; where they make their nest, and often bring forth their young. When they spy any animal they can master, and there are but few in the forest but what are inferior, they dart down upon it with inevitable exactness.

The whole tribe of animals of the panther kind, with long tails, are chiefly inhabitants, as was said, of the torrid zone; but those of the short-tailed kind, and particularly the lynx, is principally found in the cold countries that are bordering on the pole. The lynx is chiefly to be met with in the north of Germany, Lithuania, Muscovy, Siberia, and North America. Those of the new continent, however, are rather smaller than in Europe, as is the case with almost all their quadrupeds; they are somewhat whiter also, but in other respects there is scarce any difference to be found among them.* This animal has been called by some *Lupus Cervarius,* or a creature compounded between a wolf and a stag; but for what reason is hard to guess; it no way resembles either in shape or disposition. In its nature, it exactly resembles the cat, except that, being bigger and nearly two feet long, it is bolder and fiercer. Like the cat, it climbs trees, and seeks its prey by surprise; like the cat, it is delicate and cleanly, covering its urine with its paws; and it resembles the wolf in nothing except its cry, which often deceives the hunters, and induces them to think they hear a wolf and not a lynx. This animal, also, is rather more delicate than the cat; and, after having once feasted

* Buffon.

upon its prey, will never return to it again, but hunts the woods for another. From hence may have arisen the common report of the lynx having, of all other quadrupeds, the shortest memory. This, however, is not the only idle story that has been propagated of it: as if its seeing with such perspicuity as to perceive objects through walls and mountains; as of having its urine of such a quality, as to harden, and become a precious stone; with several others, propagated by ignorance or imposture.

The Syagush and the Serval are both so like all the rest of the cat kind in disposition, that it is but repeating the same account once more to give their distinct history. As the lynx is found only in cold countries, so the syagush is to be met with only in the warm tropical climates. It is used, in the same manner as the ounce, for hunting; but it seems to have a property which the other has not; namely, that of being able to overtake its prey by pursuing it. Whether this is performed by having a finer scent than the former, or greater swiftness, we are not informed; being only told that when it overtakes either the gazelle or the antelope, it leaps upon their backs, and, getting forward to their shoulders, scratches their eyes out, by which means they become an easy prey to the hunters. Some have called this animal the lion's provider; and it is said that when it calls him to pursue his prey, its voice very much resembles that of one man calling another.* From hence we may conjecture that this animal pursues its prey in full cry,

* Thevenot, vol. ii. p. 114.

and that the lion only follows to partake or seize the spoil. The same account is given also of the jackall; and very probably it may be true, not only of these animals, but of some others, since it is natural enough to suppose that the lion will pursue whenever he is taught to discover his prey.

We had one of these animals a few years ago sent over from the East Indies, but it was not able to endure the change of climate, and it died in a very short time after it was brought to the Tower. Whether consumed by disease or not I cannot tell, but it seemed to me much slenderer than the cat or the lynx, and its ears were much longer; however, it is a very strong creature for its size, and has been known to kill a large dog in single combat: * nevertheless it is, like all of the cat kind except the lion, remarkable for its cowardice, and will never, except in cases of necessity, attack an animal that is its equal in strength or activity For this reason, when brought into the field, and put upon a service of danger, it obstinately refuses, and is alert only in the pursuit of animals that are too feeble for resistance, or too timid to exert their strength.

From what has been said of this rapacious tribe, we perceive a similitude in the manners and dispositions of them all, from the lion to the cat. The similitude of their internal conformation is still more exact; the shortness of their intestines, the number of their teeth, and the structure of their paws. The first of this class is the Lion, distinguishable from all the rest by his strength, his

* Buffon.

magnitude, and his mane. The second is the Tiger, rather longer than the lion, but not so tall, and known by the streaks and the vivid beauty of its robe; including also the American tiger or cougar; distinguishable by its size, next that of the tiger, its tawny colour, and its spots. The third is the Panther and the Leopard. The fourth is the ounce, not so large as any of the former, spotted like them, but distinguishable by the cream-coloured ground of its hair, and the great length of its tail, being above the length of its body. The fifth is the Catamountain or Tiger Cat, less than the ounce, but differing particularly in having a shorter tail, and being streaked down the back like a tiger. The sixth is the short-tailed kind, namely, the Lynx, of the size of the former, but with a short tail, streaked, and the tips of its ears tufted with black. The seventh is the Syagush, differing from the lynx in not being mottled like it, in not being so large, and in having the ears longer, though tipped with black, as before. The eighth is the Serval, resembling the lynx in its form, and the shortness of its tail; streaked also like it, but not having the tips of its ears tufted. Lastly, the Cat, wild and tame, with all its varieties; all less than any of the former, but, like them, equally insidious, rapacious, and cruel.

This whole race may be considered as the most formidable enemy of mankind; there are others, indeed, stronger, but they are gentle, and never offer injury till injured: there are others more numerous, but they are more feeble, and rather look for safety by hiding from man, than opposing him. These are the only quadrupeds that make good

be contented to remain for ever in the same situation, perfectly satisfied with sensual pleasures and undisturbed repose. The women of these countries are the greatest slaves upon earth; sensible of their weakness, and unable to resist, they are obliged to suffer those hardships which are naturally inflicted by such as have been taught that nothing but corporeal force ought to give pre-eminence. It is not, therefore, till after some degree of refinement, that women are treated with lenity; and not till the highest degree of politeness, that they are permitted to share in all the privileges of man. The first impulse of savage nature is to confirm their slavery; the next, of half barbarous nations, is to appropriate their beauty; and that of the perfectly polite, to engage their affections. In civilized countries, therefore, women have united the force of modesty to the power of their natural charms; and thus obtain that superiority over the mind, which they are unable to extort by their strength.

END OF THE FIRST VOLUME.

Printed by T. C. Hansard, Peterborough-court, Fleet-street, London.